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BREEDING OF THE SALT MARSH SHREW

BY RICHARD F. JOHNSTON AND ROBERT L. RUDD

Salt marsh shrews (*Sorex vagrans halicoetes*) are common inhabitants of some of the San Francisco Bay salt marshes in California. Their numbers in favorable marshes form perhaps 10 per cent of the mammalian fauna present, the rest of which is chiefly composed of *Microtus californicus, Rattus norvegicus, Mus musculus,* and *Reithrodontomys raviventris,* all of which are more abundant than shrews. There is no study yet reported on the biology of salt marsh shrews, and indeed little on the species S. *vagrans* throughout its range. Comparative material in this paper has been drawn mainly from Clothier (1955), Hamilton (1940, 1944, 1949), Jameson (1955), Blossom (1932), and Dehnel (1952); only the first of these deals with *Sorex vagrans.*

Field work was done from 1949 to 1955, although the major part of this time was spent on studies other than this one. Trapping was undertaken on all San Francisco Bay marshes inhabited by S. *v. halicoetes;* observations on nesting activity were carried out on San Pablo marsh, Richmond, Contra Costa County; a collection of owl pellets was also made at this locality. Observations on captive shrews were made at the Museum of Vertebrate Zoology (Rudd, 1953).

The environment.—The San Francisco Bay salt marshes are in an area of Mediterranean climate. Temperatures average perhaps 55° F. through the year, minima of 28° to 30° and maxima rarely of 90° to 100° occurring. Rainfall averages 18 to 25 inches a year and falls in the period from November to April. Thus, there is a long summer dry season. However, because of the summer high tides, dryness may reach critical levels for salt marsh shrews only in September and October.

The lower parts of salt marshes, 3 to 6 feet above sea level, are grown to extensive pure stands of cordgrass (*Spartina foliosa*); this part of the marsh is covered at least once a day by tidewater. Higher ground, 5 to 9 feet above sea level, is covered by the *Salicornia* association, characterized by pickleweed (*Salicornia ambigua*) and saltgrass (*Distichlis spicata*), and on especially raised areas there is gumplant (*Grindelia cuneifolia*). A full discussion of the relationship of plant distribution to tide levels may be found in Hinde (1954).

Habitat.—Sorex vagrans halicoetes frequents those parts of salt marshes that offer dense cover, an abundance of invertebrate animals as food, suitable nesting

and resting sites, and fairly continuous ground moisture. The shrew metropolis is found on the medium high marsh, about 6 to 8 feet above sea level, and it extends to lower marsh areas not regularly flooded by tidewater. Suitable areas within this expanse of marsh characteristically have an abundance of stranded driftwood and other detritus scattered in *Salicornia*, which ordinarily reaches one to two feet in height. Under these pieces of wood, moisture is retained fairly well into the autumnal dry period, and amphipods, isopods and other invertebrates are common in most seasons of the year. Nesting and resting cover for shrews is provided by the same driftwood and plant material. The latter includes the living *Salicornia*, but equally important is the dead material left by tidewater; most of this is *Spartina* duff. The higher marsh, 8 to 9 feet in elevation, being dry and with minimal cover, has few or no shrews and the lower *Spartina* zone, subject to daily floods and without heavy cover, is devoid of them.

Numbers.—No census of shrews on San Pablo Marsh was taken. However, a variation in relative numbers was noted in the period from 1951 to 1955, based on the number of active nests found. Shrews were abundant in 1952 and 1955, moderately abundant in 1951 and 1954, and scarce in 1953. The number of nests found with young was: 1951, 1; 1952, 11; 1953, 0; 1954, 4; 1955, 10. In 1953 Johnston was watching carefully for nesting activity and found but three nests, all empty, in the course of the entire year. Little additional information on fluctuation in numbers was obtained from an examination of 387 pellets of the short-eared owl (*Asio flammeus*); this owl is found on the marsh from late August to April. In 1951-52, 6.1 per cent of the items in pellets were shrews; in 1952-53, 2.6 per cent; in 1953-54, 1.0 per cent; and in 1954-55, 1.3 per cent.

Nests.—Two kinds of nest are made by salt marsh shrews. One is used for housing litters and is made presumably by females; the other, which we call the resting nest, is probably made and used by both sexes.

The breeding nest is made of dead plant matter. Fragmented leaves and stems of *Spartina* are used preferably. *Distichlis* and *Salicornia* are also used. Grasses otherwise appear infrequently and mammal hair (*Rattus norvegicus*) was noted once as a cup lining. Small pieces of paper occur in almost all fresh nests and form the topmost part of the cup, which almost always is domed. As the young grow the cup enlarges, the dome is obliterated, and the paper lost.

The walls of the nest are concentrically arranged around the cavity. The construction is substantial but since the nests are damp and placed on a wet substrate they are not as coherent as they would be were they dry. Runways enter the cavity of the cup from the sides and from beneath, through the peripheral duff; the cup is thus not open to view until the young are two to three weeks old. Clothier (1955:218) describes a nest of *S. vagrans* in Montana as merely a ball of dried grass with no definite nest cavity, placed in a hollow log.

The breeding nest is of variable size due partly to the shape of the plank or cover under which it is placed. The mass may be from 8 to 24 cm. by from 6 to 12 cm., and 4 to 6 cm. in depth. Cups of fresh nests measure 3 × 3 cm. to 4 × 4 cm. and 2 to 3 cm. in depth. The dome of the nest is placed frequently in a cavity in the underside of the covering structure. Such concavities are rarely found but usually show evidence of use by shrews. One such cavity in a large woodblock was occupied almost continually since observation began in 1951; four nests with young have been found under it, including one of the two found in September. Resting nests are smaller, 2 or 3 by 3 or 4 cm., and are shallow cups only. They are placed under a cover but in all cases are elevated above the soil surface in the depressed *Salicornia*. Adult shrews have been found in these nests occasionally.

BREEDING BEHAVIOR

The breeding season.—Figure 1 shows the dates and frequency of occurrence of parturition in salt marsh shrews. The histogram was constructed on 20 records of trapped pregnant shrews and on 19 records of nests found with young in them. A certain number of days was added to the date of capture of the pregnant females in accordance with their state of pregnancy to get an assumed date of parturition; a certain number of days was subtracted from the date young were found, in accordance with their age, to get assumed dates of parturition. This is a convenient way in which to express these data, but it should be noted that they are from several years and the cycles unquestionably vary from one year to another. The principal season for births extends from the last of February to the first of June; the modal date for parturition in the spring is April 25, and more than half of all litters are born in April. Subsequent to early June there is a three-month gap in our records of breeding; there is a small amount of breeding in middle and late September.

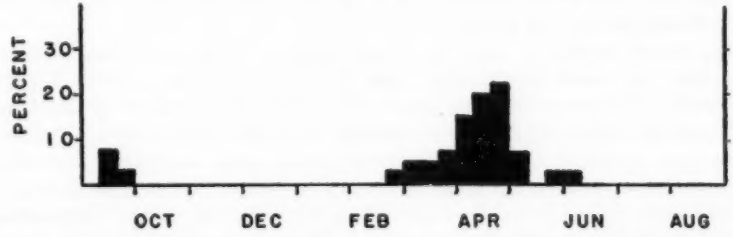

FIG. 1.—Breeding season of salt marsh shrews as shown by frequency of parturition. Vertical columns represent ten-day periods with the 5th, 15th, and 25th of each month as medians. $N = 39$.

There may not be a complete cessation of breeding in the summer months; animals capable of breeding are not common in the population at this time. Postpartum mating and double litters probably occur in the salt marsh shrew; Clothier (1955:218) found this to be true of *S. vagrans* in Montana, and it

has been established for *Blarina* and S. *fumeus* in New York (Hamilton, 1949: 259), in S. *trowbridgei* in the Sierra Nevada of California (Jameson, 1955:345), and in captive S. *araneus* (Dehnel, 1952). However, it may be that the only occurrence of double litters in salt marsh shrews is that represented (Fig. 1) by the small number of births in late May and June.

Probably it is mainly the young of the year that breed in the fall, for it is about this time that young shrews appear to be nearly adult in linear size and in behavior, and adults are almost completely absent from the population then. There is no indication of breeding activity in the winter.

Litter size.—Gestation in the salt marsh shrew lasts about 20 days. Figure 1 can thus be taken to represent the seasonal occurrence of first dates of pregnancy in the population if 20 days are subtracted from the dates in it. Average litter size is 5.16 young; numbers of young are distributed as follows:

Size of litter	2	3	4	5	6	7	8	9
Number of occurrences	1	5	6	11	11	2	2	1

The average size of litters *in utero* is 5.55 and in the nests 4.74. The discrepancy of 0.81 young probably represents combined mortality due to resorption, birth trauma, and postnatal inviability of various kinds occurring within about the first week of life which is the time, on the average, when our records on young in nests begin. Litters totally resorbed or killed after birth are not included in our records giving the mean of 4.74; thus, this is a figure for surviving litters. Mortality from the time of conception to the age of about 7 days postpartum therefore is not less than 15 per cent.

Clothier (1955:218) found mean litter size *in utero* to be 6.4, with a range of 2 to 9, in S. *vagrans* in Montana. It is possible that the higher mean count in Montana indicates that S. *vagrans* varies in litter size in a manner parallel to the geographic variation in clutch-size of many birds (see, for example, Lack, 1947). Such variation commonly is associated with increases in altitude, latitude and continental climate (Lack, *op. cit.;* Johnston, 1954), but the proximate factors are not yet known.

The female begins to wean the young at about 16 days, and this process is completed by about the 25th day. The young stay in the nest to perhaps the 5th week. This group situation is not truly social, for members of one family only are involved in it. The major activity of young in these groups while in the nest is huddling together, apparently to conserve body heat; nonsibling young are intolerant of one another, at least in captivity (Rudd, 1953:119). It is not known if the familial bond extends to activities outside the nest; individuals doubtless leave periodically to forage, however.

DEVELOPMENT OF THE YOUNG

The growth curve of young salt marsh shrews shown in the diagram (Fig. 2) depends on aging the individuals at the time of capture. Three basic categories were used: one week, unfurred, eyes closed; two weeks, fur dorsally, eyes open, teeth not erupted; and three weeks, heavy pelage, teeth erupted. Within each of these categories individuals were assorted as follows: category

1, younger if body red in color, older if pink and a slight gray cast of growing hairs apparent; category 2, younger if pelage thin and eyes closed, older if pelage thicker and eyes clearly open; category 3, younger if teeth not fully erupted, older if clearly erupted. The ages of individuals plotted in Figure 2 are derived from estimated deviations from weekly ages according to these criteria.

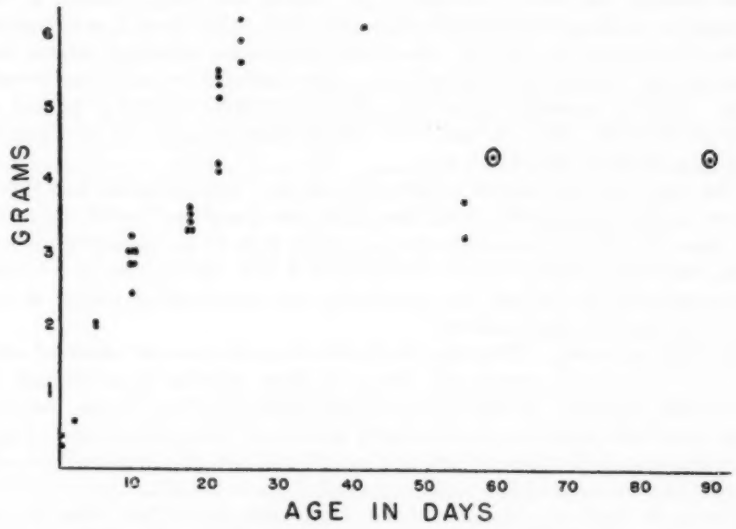

FIG. 2.—Weights of young salt marsh shrews. Encircled readings represent mean weights of thirteen individuals apiece; see text for details.

The first three and last three individual weights are of animals born and kept in captivity; these are indicated by triangles. The encircled dots placed at 60 and 90 days represent mean weights of juvenile animals captured on marshes by traps; 13 individuals of both sexes are involved in each mean reading. These animals are not precisely 60 and 90 days old, but they were taken in July and August, respectively; on the basis of our curve on incidence of birth (Fig. 1) we have assumed that the majority captured in each of those two months were two and three months old, respectively.

At birth *S. vagrans halicoetes* weighs about 0.5 gram. A similar birth weight datum for *S. cinereus* is 0.1 gram (Blossom, 1932) and for *Cryptotis parva*, 0.32 gram (Hamilton, 1944:6). After birth, weight gain is rapid and apparently constant to the age of one month, at which time shrews reach 5 to 6 grams. After this time a drop to a relatively constant weight of between 4 and 5 grams occurs, and this weight is maintained until December and January (Rudd,

1955:335), at which time increases coincident with the onset of breeding activity are noted to a maximum of 8.4 grams in males and 7.7 grams in females.

The most important fact to be seen in the diagram on weight gains (Fig. 2) is that shrews one month of age are heavier than shrews two and three months old. This specific type of weight relationship to age has not before been clearly demonstrated in *Sorex*. However, Figure 1 of Hamilton (1940:486) on S. *fumeus* shows a decline in weight of juvenile animals in the period from June through July when one-month old animals are fairly common in the population of young. Additionally, Brambell (1935:9;55) found that S. *araneus* is heavier one or two months after birth than in the following winter and early spring. Among other mammals nothing similar is found, to our knowledge; *Microtus pennsylvanicus* (Hamilton, 1937:503), probably typical of rodents generally, shows a steep but smooth curve leveling off at about 80 days to a relatively constant value.

The cause for this drop in weight after 30 days may lie in the fact that a shrew family stays together until the young are about one month old; until this time they live a semi-social existence, have little or no aggressive interactions, and they conserve heat by huddling in a ball. Subsequent to this time the young disperse through the population and expend much energy in the course of becoming independent.

Mortality of young.—The young in 15 of the nests found were observed until they were about three weeks old. These 15 litters included 61 individuals (1 to 6 young per litter) of which 35 were still alive after three weeks. Survival from near birth until just after weaning was about 55 to 60 per cent. Since mortality around the time of birth is about 15 per cent, less than half the salt marsh shrews conceived live to the age of 21 days.

Causes of death to shrews in the nest are difficult to find. One known cause is drowning due to high tidewater; four, or 17 per cent, of the dead young died this way. Doubtless another cause is death of the attendant mother shrew. Possibly 10 (39 per cent) of the deaths were due to this; the proximate causes of death would be starvation, cold and exposure. No cause can be indicated for the remaining deaths. Predation by *Rattus norvegicus* is a possibility, but we have no evidence. Avian predators do not take young shrews before their dispersal from the family group; indeed predatory birds are unimportant as a large-scale mortality agent to adult salt marsh shrews.

There is no evidence of a differential survival due to size of the litter. The mean litter size of those observed is about 4 individuals. The survival rate in litters of 2, 3 and 4 was 56 per cent; in litters of 5 and 6 it was 57 per cent.

SUMMARY

Sorex vagrans halicoetes on San Francisco Bay salt marshes in California lives mainly in the *Salicornia* zone and finds foraging, breeding, and resting sites under stranded driftwood. The season for births runs from late February to early June; a small amount of breeding occurs in September. Mean litter size *in utero* is 5.55 and in nests 1 to 2 weeks old it is 4.74; mortality to the age

of about one week in surviving litters is thus at least 15 per cent of total implantations. Young shrews gain weight rapidly, reaching 5 to 6 grams at about 30 days of age; following dispersal from the nest, weights decline and 2- and 3-month old shrews weigh about 1 gram less. Survival of young from shortly after birth to 3 weeks is 55 to 60 per cent; litter size has no influence on mortality.

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Dept. of Biol., New Mexico A. & M. College, State College, N. Mex, and Department of Zoology, University of California, Davis. *Received February 20, 1956.*

NOTES ON THE MAMMALS OF THE BAHAMAS WITH SPECIAL REFERENCE TO THE BATS

By Karl F. Koopman, Max K. Hecht and Emanuel Ledecky-Janecek

To the student of insular faunas, the West Indies are of considerable interest since they represent, on the whole, a characteristic derivative of the Neotropical region, depauperate, yet presenting some peculiar features. Of this larger Antillean assemblage, the Bahamian fauna constitutes, in some respects, a particularly interesting fragment as a result of its peripheral and northern position, it being the only part of the West Indies which extends into the temperate zone.

The last complete critical listing of the native Bahamian mammal fauna is that of G. M. Allen (1911). While only a few papers have appeared since which have added any new records (Allen, 1937; Allen and Sanborn, 1937; Koopman, 1951; Lawrence, 1934; Shamel, 1931), there is considerable additional material hitherto unreported. Recently, two expeditions to the Bahamas made collections of mammals, chiefly bats. A study of these collections made a general resurvey of the mammalian fauna of these islands particularly desirable. The first of these collections was that made on several islands by George Rabb and Ellis B. Hayden, Jr., as members of the Van Voast-American Museum of Natural History expedition during the winter and spring of 1953. The second collection was made by the writers on Exuma, an island previously uncollected for living mammals, in August and September of 1953. (See Hecht, 1955, for a list of localities collected.)

In the following systematic accounts, special mention will be given to specimens collected on these two expeditions as well as to important previously collected material hitherto unreported in the literature. (The senior author is responsible for all taxonomic judgments.) Finally, an attempt will be made to draw certain conclusions as to the geographical derivation of the mammalian fauna.

MAMMALS OTHER THAN BATS

Only two species of native land mammals other than bats are known from the Bahamas, a raccoon, *Procyon lotor maynardi*, and a short-tailed hutia, *Capromys* (*Geocapromys*) *ingrahami*. Of the first, we can add to the account given by Goldman (1950) by mentioning that the Museum of Comparative Zoology possesses a series of seven individuals collected by Barbour and Greenway in 1933-34. Inspection of these specimens reveals that the cranial and dental characters cited by Goldman on the basis of three specimens do not hold for the larger series. We are therefore inclined to consider *maynardi* as at best no more than a subspecies of *P. lotor*. *Procyon l. maynardi* is still known only from New Providence, though another form, *P. l. elucus* of mainland Florida, has been introduced on Grand Bahama (Sherman, 1954).

Capromys ingrahami was originally described as a living animal from the Plana Cays, to which at present it appears to be confined. In 1934, however, Barbara Lawrence described two fossil subspecies, *C. i. abaconis* from Great Abaco, and *C. i. irrectus* from Crooked, Long, and Eleuthera. In 1937, G. M. Allen recorded the latter as a fossil from Exuma. The 1953 Exuma expedition obtained a large amount of cave fossil material pertaining to this subspecies on both Great and Little Exuma (Pigeon Cay and Williamstown), but it appears to add little to Allen's account except to affirm the former great abundance of this species on Exuma. The Van Voast-American Museum expedition obtained three specimens of *C. i. ingrahami* on East Plana Cay. We follow Mohr (1939) in considering *Geocapromys* a subgenus of *Capromys*.

BATS

Eleven species of bats have been recorded from the Bahamas and thus make up the bulk of the native land mammalian fauna of these islands. Since the status of each of the various species in the Bahamas is quite different, they will be considered individually in the following accounts.

Mormoops blainvillii.—This bat is known only by a single fossil fragment from Little Exuma (Koopman, 1950). An attempt was made to obtain more material from the original locality, but to no avail (see Hecht, 1955). Fossil collecting is difficult in the Bahamas, since most caves have been thoroughly cleaned of cave earth for use as fertilizer. The available fossil material seems also to be rather poor in bats.

Macrotus waterhousii.—Two Bahamian subspecies are recognized, being distinguished by size, coloration, and noseleaf form. Of these, *M. w. heberfolium* is still known only by the type specimen from Providentialis island in the Caicos (Shamel, 1931). *M. w. compressus*, described first from Eleuthera, is recorded by Allen (1911) also from New Providence, Andros, and Long. Allen and Sanborn (1937) reported it from Cat, while the United States National Museum has two specimens from Watling (USNM 217271, 217272). The American Museum of Natural History has two from New Providence and one from Andros. A single specimen collected by Rabb from Darby island (AMNH 164252) and three collected by us from Great Exuma (AMNH 167110-167112—one each from Pigeon Cay, Georgetown, and Isaac's Cay [called Isaac's Key in Hecht, 1955]—add the Exuma chain to the places where this bat occurs. Fossils of this species have been found twice, once on Little Exuma in the cave where the single mandible of *Mormoops* also was found (Koopman, 1950). A second fossil was obtained by us in 1953 from a cave near the Forest settlement on Great Exuma and is, like the first, represented by a single mandible. All these specimens seem to be typical *M. w. compressus*, although the individuals from Watling are too young for their precise status to be certain. The subspecies, however, is also known from islands farther south and east. Shamel (1931) recorded it from Acklin; the Museum of Comparative Zoology has a single skull from Crooked (MCZ 30355) which was mentioned by Lawrence (1934). Fi-

nally, Rabb collected four specimens from Great Inagua (AMNH 164253, 164254, 166770, 166771). All these individuals, while best referred to *M. w. compressus*, approach *M. w. heberfolium* of the Caicos and *M. w. waterhousii* of Hispaniola in their large size and more robust skulls. *Macrotus* appears, therefore, to be one of the most widespread of Bahamian bats, though its absence from the most northern islands (Grand Bahama and the Abacos) is probably real. It apparently always spends the daytime in caves or cavelike structures, where it seems invariably to occur in the relatively light zone near openings.

Lonchorhina aurita.—This bat is known only by a single specimen from New Providence (Allen, 1911). It is probably only accidental in the Bahamas since the species is otherwise known from nowhere nearer than Central America.

Glossophaga soricina.—This bat was recorded only once from the Bahamas, probably from New Providence (Allen, 1911). It was almost certainly accidental since the subspecies to which it was assigned, *G. s. antillarum*, the only one in the West Indies, is otherwise confined to Jamaica.

Artibeus jamaicensis.—The Cuban subspecies, *A. j. parvipes*, was recorded by Shamel (1931) from Great Inagua. The American Museum of Natural History also has 15 specimens of this form from the same island which Coleman and Klingel collected. Rabb obtained 29 from Great Inagua together with three from Mayaguana (AMNH 164249-164251). In both places they were found in caves, where they tended to roost well back from any openings.

Erophylla sezekorni.—Two Bahamian subspecies are customarily recognized, apparently distinguished only by slight average differences in coloration as well as in size of skulls and teeth. One (*E. sezekorni mariguanensis*) was described by Shamel (1931) from Mayaguana and the Caicos and is still known only from these islands. The other, *E. s. planifrons*, was originally described from New Providence and was recorded by Allen (1911) from Great Abaco, Eleuthera, and Long. Allen and Sanborn (1937) recorded it from Cat, while the Museum of Comparative Zoology also has specimens from Crooked (MCZ 28315-28321). The American Museum of Natural History has three from New Providence, and Rabb also collected 27 topotypes. We obtained 17 bats of this subspecies (AMNH 167113-167129) from two caves, one on Great Exuma (Pigeon Cay), the other on Little Exuma (Pasture Cave near the Ferry). In all three places visited by Rabb and ourselves in 1953, this species was found in great numbers, but only in the farther end of each cave where it was darkest. Great variation in color was noted, some individuals, irrespective of sex, being gray, others brown, and some intermediate. Besides these specimens collected in the flesh, a mandible and a rostral fragment have also been obtained from the surface deposit removed from the floor of the cave near the Forest settlement. Comparison of Bahamian with Cuban specimens convinces us that Allen (1917) was correct in considering *E. planifrons* a subspecies of *E. sezekorni*.

Natalus (*Chilonatalus*) *tumidifrons*.—This bat is known to live only on Watling and Great Abaco (Allen, 1911). The American Museum of Natural History

has a single specimen from Great Abaco. Interestingly enough, however, a single mandible was recovered from the cave near the Forest settlement on Great Exuma, far south and west of its present known ranges.

Natalus (*Nyctiellus*) *lepidus*.—The bat was first recorded from the Bahamas by Allen and Sanborn (1937), who mention specimens from Long and Cat. The Museum of Comparative Zoology also has a series from Eleuthera (MCZ 28585-28596). We obtained five individuals (AMNH 167130-167134) from a single cave on Little Exuma (Pasture Cave near the Ferry), and also recovered a single fossil mandible from the cave near the Forest settlement. Bahamian specimens do not differ appreciably from Cuban ones. We follow Dalquest (1950) in considering *Chilonatalus* and *Nyctiellus* subgenera of *Natalus*.

Eptesicus fuscus.—For a long time this species was known in the Bahamas only from New Providence, *E. f. bahamensis* being recognized as the race. In 1937, Allen and Sanborn recorded it from Long and Watling, both southeast of New Providence, these specimens being allocated to the Cuban subspecies, *E. f. cubensis* (= *E. f. dutertreus*). Dr. Yngve Löwegren of the Zoological Institution of Lund University has written us that the Institute has some 30 specimens from Andros collected by Dr. Nils Rosén in 1908. These have also been identified as *E. f. cubensis* by Dr. Olauf Ryberg. The 1953 Exuma expedition obtained 55 specimens (AMNH 167135-167189) from 8 localities (The Forest settlement, Georgetown, Rolletown, Pasture and Hog Pen caves near the Ferry, Forbes Hill, Williamstown, Pigeon Cay, Isaac's Cay) on both Great and Little Exuma between Long and New Providence. While closer to *E. f. dutertreus* than to *E. f. bahamensis*, the Exuma specimens show a distinct approach to the latter, the variation in forearm length overlapping broadly that of the New Providence series. A single *Eptesicus* mandible, recovered from the earth about 3 to 3.5 feet below the floor of a small cave near Williamstown on Little Exuma, is rather small. The mandible appears similar to those of *E. f. bahamensis* but also compares favorably with selected mandibles of *E. f. dutertreus* from Exuma. Obviously no definite statement concerning subspecific differentiation can be made on the basis of this single mandible. In Exuma this species was usually found in caves but also in houses. No preference for any particular part of a cave was noted. We follow Shamel (1945) in considering *cubensis* (= *dutertreus*) and *bahamensis* to be subspecies of *Eptesicus fuscus*.

Lasiurus borealis.—The precise allocation of the red bats of the Bahamas is still somewhat uncertain. G. M. Allen (1911) records this species on the basis of two specimens, only one of which he had examined, from New Providence, tentatively identifying the Bahamian *Lasiurus* as *seminolus*, the form occurring in the southeastern United States. He did this on the basis of size and coloration, though he admitted that neither were typical of conditions in *seminolus*. In 1937 Allen and Sanborn recorded a single specimen from Cat, which was allocated to the Hispaniolan *L. minor*, described by Miller in 1931. Other unrecorded museum material from the Bahamas exists. The Chicago Natural History Museum has three from Long (CNHM 46067-46069), seven from Great

Inagua (CNHM 15075-15081), and one from the Caicos (CNHM 15082) which, though collected as far back as 1891, in the case of the latter two localities, have never been mentioned in the literature. The British Museum also has specimens from both New Providence and Andros (BM 3.10.3.6). Unfortunately most of the material available to us is unsatisfactory (all the Inagua and Caicos skulls are broken). However, we are inclined to agree with Allen and Sanborn (1937) that Bahamian red bats are best referred to *L. minor*. This form is currently considered a full species, apparently largely because *L. b. borealis* and *L. seminolus*, virtually identical except for color, breed at the same localities in Alabama and South Carolina and appear to behave as valid species (Barkalow, 1948; Coleman, 1950). If this were the case, it would follow that the more distinct Antillean forms should also be regarded as distinct species. While the evidence is conclusive that *L. borealis* and *L. seminolus* are not simple geographical races, the alternative—that color phases are involved—has not been ruled out. The color character breaks down in the Inagua series, where two individuals are dark like *seminolus*, two are red like *borealis*, and the other three are intermediate. The situation on the mainland appears to be more complex. Here too, intermediates certainly occur, but they appear to be considerably less common than on Inagua. We feel, however, that unless and until *borealis* and *seminolus* are conclusively shown to be species rather than color phases (as by the demonstration that young are always of the same color type as the mother, even at localities where both forms occur), the best course is to consider all the red bats of the West Indies as races of *L. borealis*. The name of the Hispaniolan and Bahamian form which seems indicated is, therefore, *Lasiurus borealis minor* Miller.

Tadarida (*Tadarida*) *brasiliensis*.—Originally described from Eleuthera, the subspecies *T. b. bahamensis* was also recorded by Allen (1911) from Long and the Abacos. Surprisingly enough, it has not been recorded from any other Bahamian island until the 1953 Exuma expedition obtained 61 specimens (AMNH 167190-167250) from five localities on both Great and Little Exuma (Rolleville, Rolletown, Hog Pen cave near the Ferry, Williamstown, Pigeon Cay). At four of these places, the species was found in caves; at Rolleville it was found in an old schoolhouse. In the four caves it occurred close to *Eptesicus*, though the two species kept somewhat separate, but *Tadarida* showed a greater tendency to form dense clusters. This was another species in which considerable variation in color was noted, one extreme being brownish gray, the other a dark gray without a trace of brown. We follow Allen (1911) and Schwartz (1955) in considering *bahamensis* a subspecies of *T. brasiliensis*, since all the members of the *brasiliensis* group are allopatric and very similar, more so than are any of the sympatric American species in the subgenus *Tadarida*.

DISCUSSION

Before considering the zoogeographical conclusions and problems which arise, a brief consideration of the basic geography of the Bahamas seems in

order. The archipelago consists of low islands, the highest point being only 400 feet above sea level and most islands rising only to 50 or 100 feet. The channels separating these islands all conform to one of two types, either very shallow, usually much less than 100 fathoms, or quite deep, considerably more than 100 fathoms. This means that during the fluctuations in oceanic levels that occurred during the Pleistocene, the Bahamas were sometimes almost completely submerged, while at other times the shallow banks formed continuous dry land. The latter configurational change is the more important with respect to mammals both because it was more recent (corresponding to the Fourth Glacial period), and because it had the positive effect of permitting mixing of separated faunas rather than the negative one of wiping them out. When we consider the present islands in relation to the larger banks, we see the picture shown in Fig. 1. To a large extent, the banks rather than the individual islands are the more important units in zoogeographical considerations, since they represent older and more permanent entities. The individual islands, on the other hand, are continually being divided by wave action or united by the filling up of intervening shallow water by sediments.

Procyon and *Capromys* (*Geocapromys*) present no real problems in zoogeography as far as the Bahamas are concerned. The first is generally agreed to have reached these islands from Florida. This is supported by morphological resemblance, geographical proximity, and the absence of raccoons from any other part of the Greater Antilles. The subgenus *Geocapromys* is confined to

FIG. 1. — Map of the Bahamas showing the outlines of the Banks in broken lines, the islands indicated by numbers as follows: 1 = Grand Bahama; 2 = Abacos; 3 = Andros; 4 = New Providence; 5 = Eleuthera; 6 = Cat; 7 = Exuma; 8 = Long; 9 = Rum; 10 = Watling; 11 = Samana; 12 = Crooked; 13 = Acklin; 14 = Plana; 15 = Mayaguana; 16 = Little Inagua; 17 = Great Inagua; 18 = Caicos; 19 = Turks. Present occurrences of the better-known species of bats in the Bahamas are indicated as follows: M = *Macrotus waterhousii;* A = *Artibeus jamaicensis;* ∃ = *Erophylla sezekorni;* C = *Natalus (Chilonatalus) tumidifrons;* N = *Natalus (Nyctiellus) lepidus;* E = *Eptesicus fuscus;* L = *Lasiurus borealis;* T = *Tadarida brasiliensis.*

the Bahamas, Cuba, Jamaica, and Swan island in the Caribbean. It is not known ever to have occurred in either Florida or Hispaniola, so that the short-tailed hutia very probably reached the Bahamas from Cuba. This is also suggested by its Bahamian distribution, since it is known as a fossil from several islands of the Great Bahama Bank, nearer Cuba, but is not known from the islands nearest Hispaniola (Great Inagua and the Caicos).

Of the bats, three (*Mormoops*, *Lonchorhina*, and *Glossophaga*) are too poorly known in the Bahamas to be profitably analyzed zoogeographically. It is interesting to note, however, that all are southern forms, the geographically closest populations of these three genera being in Cuba and Hispaniola, in Central America, and in Jamaica, respectively. It is improbable that any of the Bahamian bats have come from Florida.

Of the remaining eight species (indicated in Fig. 1), *Artibeus* has a marginal distribution, being known only from two islands in the southeast. It is such a common bat wherever it occurs in the West Indies that it is most unlikely that it really has a wide distribution in the Bahamas. This, together with its lack of differentiation from the Cuban form, *A. j. parvipes*, makes it appear very likely that it is a rather recent invader from Cuba and not from Hispaniola, which is inhabited by the larger subspecies, *A. j. jamaicensis*.

Natalus (*Chilonatalus*) has, on the other hand, a peripheral distribution, being known, by living populations, only from the Little Bahama Bank to the north and from Watling island to the east. Although a rather well-differentiated form (the only endemic species of Bahamian bat), it is reasonably certain that it has reached the Bahamas from Cuba, since the subgenus also occurs there and is otherwise known only from Jamaica and from Providencia island in the Caribbean. Its probable real absence, at present, from any of the islands of the Great Bahama Bank may best be explained by the presence there of an apparently later arrival, the related *Natalus* (*Nyctiellus*), which is known from at least four of the Great Bahama Bank islands. According to this hypothesis, *N.* (*Chilonatalus*) originally occupied the Great Bahama Bank, but with the invasion of *N.* (*Nyctiellus*), it lost out in the resulting competition for the rather poor ecological niches of these relatively small islands and became restricted to peripheral islands which the later invader has not, as yet, reached. It is therefore extremely interesting that its former presence in Exuma should be confirmed by the single mandible from the Forest settlement cave.

Natalus (*Nyctiellus*) and the remaining five species of Bahamian bats occur on all six of the major islands of the Great Bahama Bank, although so far only *Macrotus* is known from all six of these islands, and only from Long are all six species known. The fact that five of these species were obtained on Exuma, where none was known before, makes it seem likely that the apparent absences, particularly of three of the species from Andros, are due to inadequate collecting. The derivations and general pattern of distribution of these species in the Bahamas are, however, more diverse. Three appear to have come from Cuba, three from Hispaniola.

Natalus (*Nyctiellus*) is known only from islands on the Great Bahama Bank and, as indicated above, is probably a recent invader from Cuba. *Eptesicus* appears also to have come from Cuba, but probably earlier, since it has reached peripheral Watling island and also shows considerable geographical variation on the Great Bahama Bank, the population on the island farthest away from Cuba showing the greatest degree of differentiation from the Cuban form. The fact that the only fossil mandible of this genus obtained from Exuma agrees with those of the New Providence form, *E. f. bahamensis*, might indicate a double invasion of the Bahamas, the first giving rise to an endemic subspecies, which was subsequently partially swamped by the later-invading *E. f. dutertreus*. On this hypothesis, the populations of the more southern islands would then have had time to become more like those of Cuba, whereas New Providence, farther north, would still retain a population of the original type. There is, however, no real evidence for this hypothesis. It has also been suggested that *E. f. bahamensis* represents a persistently primitive form whereas *E. f. dutertreus* is more specialized. This appears improbable, however, since most American members of the *Eptesicus fuscus* group are as large as *E. f. dutertreus* or larger. These would include *E. f. hispaniolae* of Hispaniola, *E. f. wetmorei* of Puerto Rico, and all the mainland races of *E. fuscus*.

Erophylla, the third form with a Cuban derivation, has a much wider distribution. It not only occurs widely on the Great Bahama Bank, but is also known from the Little Bahama Bank, the Acklin-Crooked island Bank, Mayaguana, and the Caicos. Two subspecies are recognized in this area but appear to be rather weakly differentiated. There is little likelihood that *Erophylla* reached the Bahamas from Hispaniola since, as G. M. Allen (1917) has shown, the genus divides neatly into two groups, an eastern (*bombifrons*) which inhabits Hispaniola and Puerto Rico, and a western (*sezekorni*) which occupies Cuba and Jamaica. All Bahamian populations clearly belong to the western group.

Of the species which appear to have reached the Bahamas from Hispaniola, *Macrotus* is the most widely distributed, occurring on all the principal islands of the Great Bahama Bank together with Watling, the Acklin-Crooked island Bank, Great Inagua, and the Caicos. Its absence from the Little Bahama Bank to the north is probably significant, but whether this is due to its failure to cross the intervening water barrier or to ecological factors is not known. The Caicos form may well represent a separate invasion from Hispaniola, but this is difficult to say until more material of *M. w. heberfolium* can be obtained, the subspecies being known at present from the type specimen alone. As mentioned above, populations from the southeastern banks morphologically approach *M. w. waterhousii* of Hispaniola, thus strengthening the belief that this represents the point of origin of the Bahamian subspecies. This probably also indicates that differentiation has occurred in the course of the spread north, although it is also possible, as in *Eptesicus*, that a double invasion is involved. Even populations from the Great Bahama Bank are more like *M. w. waterhousii* than like *M. w. minor* of Cuba.

As mentioned above, the Bahamian *Lasiurus* seems best referred to *L. b. minor* of Hispaniola and hence presumably came from that island, although derivation of the Hispaniolan populations from the Bahamas, which in turn had received their *Lasiurus* ultimately from Florida, is not entirely ruled out. It is therefore gratifying to find that, besides being known from four islands of the Great Bahama Bank, it occurs on Great Inagua and the Caicos as well, which lie close to Hispaniola. *Lasiurus* is not known from any other islands at present, but in view of its habit of roosting in vegetation rather than in caves or houses, and its consequent rarity in collections, this apparent absence is probably not significant.

Though the Bahamian *Tadarida* is definitely more like the Hispaniolan than like the Cuban form, it has only been obtained from the northern Little Bank and from three of the Great Bahama Bank islands. The islands to the southeast have not been thoroughly collected, however. Here again, derivation from Florida, while unlikely, is not completely excluded, since *T. b. bahamensis* is to some degree intermediate between *T. b. constanzae* of Hispaniola and *T. b. cyanocephala* of the southeastern United States, but more nearly resembling the former.

Thus it can be seen that, of the seven species known from the central and northern peripheral islands, six now occur on the Great Bahama Bank. One additional species formerly occurred there, but is probably now confined to peripheral islands to the north and west. Two of the six species now occurring on the Great Bahama Bank have also reached the Little Bahama Bank to the north. Two others, together with the form now confined to peripheral islands, have reached Watling island to the east. Three of the species inhabiting Great Bahama Bank have reached islands to the southeast of the Great Bahama Bank, where *Artibeus*, which has apparently never reached the main islands, also occurs. Thus the islands of the Great Bahama Bank have the richest bat fauna.

All the Bahama islands are, however, much impoverished faunistically in relation to the larger Greater Antillean islands. In part this is due to their smaller size and peripheral position. More important, however, is the much poorer habitat. All of the Bahama islands are low and composed entirely of limestone with a thin soil. There is hence no montane rain forest such as is found in the Greater Antilles proper, and except for the pine forests on some of the northern islands, most of the vegetation is of a scrubby xerophytic type. These northern islands, which are not in the tropics, are geographically isolated from areas of somewhat similar ecology in Florida. Therefore it is not surprising that the entire Bahamian bat fauna represents a very depauperate Greater Antillean assemblage.

As shown in the accompanying tabulation of bats of the Great Bahama Bank, the known fossil fauna is composed chiefly of species still living on these islands. Of the two which do not, one, *Natalus* (*Chilonatalus*), persists, as mentioned above, on other Bahamian islands; the other, *Mormoops*, appears to have in-

vaded the Bahamas, but subsequently become extinct there, although it still lives in the Greater Antilles proper.

Species	Living	Fossil (Exuma)
Mormoops blainvillii		+
Macrotus waterhousii	+	+
Lonchorhina aurita	?	
Glossophaga soricina	?	
Erophylla sezekorni	+	+
Natalus (Nyctiellus) lepidus	+	+
N. (Chilonatalus) tumidifrons		+
Eptesicus fuscus	+	+
Tadarida brasiliensis	+	

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SUMMARY

Of the 11 species of bats recorded from the Bahamas, 8 can be analyzed fairly satisfactorily from a zoogeographical standpoint. Five of these were almost certainly derived from Cuba, the remaining three from Hispaniola. The central islands of the Great Bahama Bank have the richest fauna, with the peripheral islands for the most part supporting only impoverished samples derived from it. The meager fossil record suggests former distributions more extensive than those of the same species today. In one especially interesting case, the fossil evidence supports the hypothesis originally based on present geographical distribution, namely that the subgenus *Nyctiellus* of the genus *Natalus* has replaced the related subgenus *Chilonatalus* from the central portion of its former range in the Bahamas.

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MARTEN HOME RANGES AND POPULATION FLUCTUATIONS

BY VERNON D. HAWLEY AND FLETCHER E. NEWBY

Live trapping was initiated in 1952 on a six square-mile area in Glacier National Park, Montana, to obtain quantitative ecological data on a population of marten (*Martes americana*). Field work for this report was conducted during the periods shown in Table 1. Investigation of marten ecology on the study area is continuing.

Methods used and description of the study area were presented previously (Newby and Hawley, 1954). The 1954 progress report did not give final figures for the size of marten home ranges and gave little information on population dynamics. The present paper will discuss these aspects of the study based on the more extensive data now available.

TABLE 1.—*Field periods and trapping effort*

YEAR	PERIOD	DAYS	TRAP UNITS
1952	August 25 through September 13	20	348
	October 17 through October 19	3	44
	December 20 through December 23	4	45
	1952 Total	27	437
1953	March 28 and 29	2	13
	May 15 through 17	3	31
	June 16 through September 25	102	1431
	November 26 through November 28	3	57
	1953 Total	110	1532
1954	January 12 through March 16	64	318
	June 13 through October 29	139	1386
	November 20 through December 29	40	320
	1954 Total	243	2024
	Grand Total	380	3993

TRAPPING SUCCESS

A total of 3,993 trap units was set during the study period, resulting in 525 captures of 85 marten (54 males and 31 females). Forty-nine marten, or 57.6 per cent, were recaptured at least once. The highest number of captures of one individual was 73 for an adult male over a period of 562 days. Male marten, with 391 captures, accounted for 74.4 per cent of the captures but composed only 62.3 per cent of the marten captured. The average trapping effort required to capture one marten was 7.6 trap units in total, but varied from 2.8 to 11.9 trap units per marten during the various quarterly periods. The winter period required the least trapping effort.

HOME RANGE

Live trapping of marten produced quantitative information on their home range size and on their relationships with each other and with the habitat. Minimum home ranges were delineated by connecting the outside points of capture as plotted on a map prepared from aerial photographs (Fig. 1). Home range areas were obtained by the use of a planimeter. This method was used because it encloses an area within which the marten was known to have been. Furthermore, it is completely objective and is well suited for use with the non-grid system of trapping (Hayne, 1949).

It could not be assumed that home ranges ended at the outside capture location when that location lay on the extreme edge of the study area. For this reason, only ranges completely surrounded by traps that did not capture the

marten were used when computing home range sizes. Although information was obtained on home ranges of 38 marten, only 11, 6 of males and 5 of females, met this requirement.

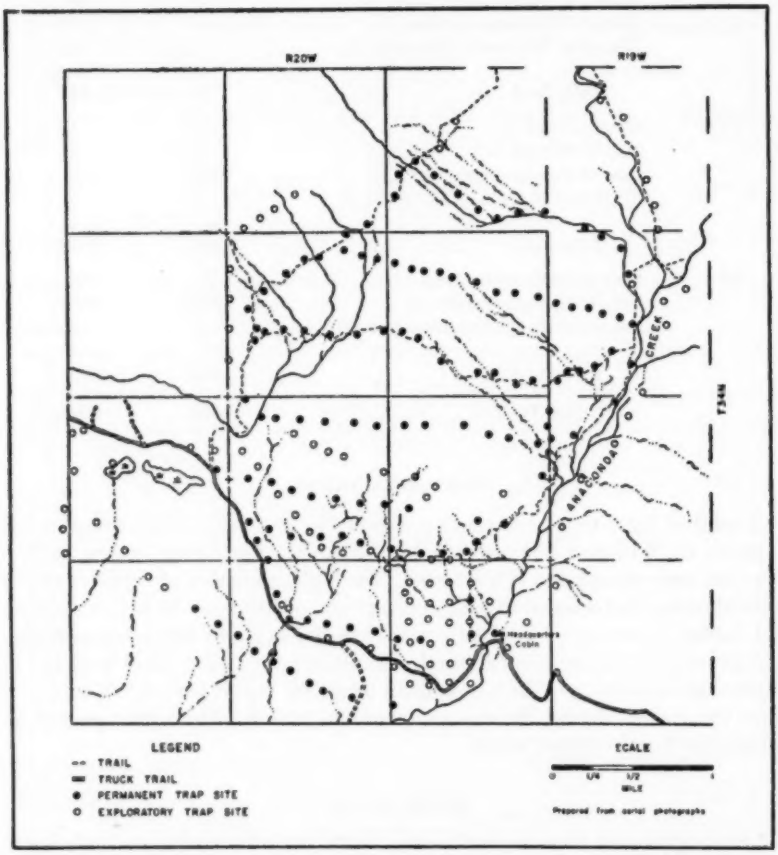

FIG. 1.—Live-trapping study area for marten, Glacier National Park, Montana.

Size.—The planimetered areas of these eleven home ranges appear in Table 2. The mean home range size of 0.92 square mile for males is significantly different (2 per cent level) from the mean of 0.27 square mile for female home ranges. This difference in the size of male and female home ranges was suggested by Newby (1951) from his investigations in Washington and by Newby and Hawley (1954) from preliminary results of the present study.

Home range sizes determined during this study differ considerably from those found by other investigators in other parts of the United States (Table 3).

TABLE 2.—*Home range size*

MALES				FEMALES			
MARTEN NUMBER	NUMBER CAPTURES	PERIOD (DAYS)	AREA (SQ. MI.)	MARTEN NUMBER	NUMBER CAPTURES	PERIOD (DAYS)	AREA (SQ. MI.)
2	73	562	1.01	4	17	521	0.20
6	27	767	1.25	10	15	660	0.23
7	34	788	1.68	11*	13	54	0.18
8*	34	236	0.89	33	10	578	0.70
9	13	521	0.35	37†	7	649	0.03
17	32	188	0.34				
		Mean	0.92			Mean	0.27

* Juvenile.

† Female No. 37 was captured over a distance of 0.6 mile along a curved portion of one trap line. Her home range apparently was too narrow for captures to be made on adjacent trap lines.

Comparison of the areas in Table 3 is of questionable value since each was arrived at through a different method. The areas of Marshall (1951) were based on tracking records, while those of Davis (1939) and Grinnell, Dixon and Linsdale (1937) were based almost wholly on trappers' reports. It will be necessary to compare figures of the present study with quantitative data obtained from similar studies in other areas in order to discover possible variations between populations.

Captures of an adult male on successive days at various times throughout the year provided records of 40 minimum daily movements. These movements ranged from 0.0 to 1.6 miles with a mean value of 0.44 mile. Since the maximum length of his home range was two miles, this marten could have traveled over most of it in a very short period.

Certain portions of the home ranges were used to a greater extent than others, as was indicated by the high trapping success in these areas. The information available, however, was not sufficient to determine the extent of the daily range.

No seasonal movements of resident marten were observed during this study. Of twenty-two marten captured in 1952, ten (5 males and 5 females) were known to be resident on the study area. Nine of these residents were present

TABLE 3.—*Home range size comparisons*

AUTHORITY	SIZE
Grinnell, Dixon and Linsdale (1937)	10-15 miles in diameter
Davis (1939)	10-25 miles in diameter
Marshall (1951)	12-15 square miles
Present study	Males: 0.92 square mile
	Females: 0.27 square mile

in 1953 while seven were still on the area in the summer of 1954. At the end of the investigation period in December, 1954, four marten (3 males and 1 female) remained from the ten residents of 1952. These marten remained on the same home range regardless of season for periods as long as 819 days.

Boundaries.—Some home range boundaries were found to coincide with various vegetative or topographic features. In August of 1953 an effort was made to determine whether home ranges extended across Anaconda Creek to the previously untrapped east side (Fig. 1). During the month both sides of the creek were extensively trapped. Previously 24 marten, 12 of which were residents, had been captured along the west side of the creek. During August seven of these residents were captured on the west side and three untagged marten on the east. Although no movement across the creek could be demonstrated at this time, in February of 1954 when the creek was completely frozen over and covered with four feet of snow, two adult males from the west side of the creek were captured at the headquarters cabin on the east. Anaconda Creek, even in summer, does not constitute a physical barrier to marten as it is only 10 to 20 feet wide and crossed by numerous logs and beaver dams.

Home range boundaries also were noted to coincide with the edge of large open meadows and burns. It was observed that on numerous occasions marten seemed to avoid entering areas without overhead cover. Such behavior would likely result in little use of meadows, unrestocked burns and open creek bottoms. These features apparently act as psychological rather than physical barriers to marten.

One portion of the north-south ridge on the study area coincided with the boundaries of home ranges in that vicinity. In 1953 neither marten on the east nor on the west crossed to the opposite side of the ridge. In 1954, however, upon loss of the residents on the east, those on the west extended their ranges across the ridge to the east side. The location of the boundaries along the ridge in 1953 was apparently an aspect of behavior between individuals rather than a direct relationship between marten and the topography.

Other home range boundaries could not be correlated with any observable change in habitat.

Spatial distribution.—Home ranges of adult marten (for purposes of this report, yearlings are included in the adult category) of like sex were rather evenly distributed with little overlap. An exception was the almost complete overlap exhibited by home ranges of two adult males. Marten of opposite sex were apparently quite tolerant of each other since the home range of a male often included the ranges of one or more females. Tolerance toward juvenile marten of either sex was indicated since their home ranges were established without regard to ranges of other marten.

Upon loss of an adult male resident in 1954, the boundaries of the home ranges of three neighboring males were extended into the area in such a manner as to occupy the vacated space. This behavior suggests that the spatial distribution of home ranges was due to some interaction between individuals of the

same sex. Dice (1952) states that such a distribution usually results from a defense of territories, although it can occur purely as an effect of the unsocial behavior of the species. No territorial defense was noted for individuals of this population. The marten, however, did exhibit anti-social behavior toward each other. Two juvenile males observed to meet in the wild growled whenever they caught sight of each other and never approached each other more closely than 10 feet, although both animals remained in a one-fifth acre area for approximately one-half hour. Fighting between individual marten apparently does occur as many marten were noted to have wounds and scars around the head and shoulders, but this was usually coincidental with the breeding season. Social tolerance was exhibited only by males and females during the breeding season and by females and young during the period of juvenile dependency.

POPULATION FLUCTUATIONS

The composition of the marten population was continually undergoing change through gain and loss of individuals (Table 4). Although marten with established home ranges tended to remain on the area, there were losses of these marten during the study period. Additional fluctuations were caused by the appearance of untagged animals.

In order to separate the marten as to the length of time between the first and last capture of each animal, three categories were set up as follows:

1. Transients were marten captured over a period not longer than one week.
2. Temporary residents were marten captured over a period longer than one week but shorter than three months.
3. Residents were marten captured over a period of three months or longer.

Forty-seven of the 85 marten captured during the study were transients, eight were temporary residents and thirty were residents. The large number of marten classified as transients indicates that many animals were only passing through the area. Thirty-eight marten in total were classed as temporary residents or residents while probably no more than twenty-seven were actually residing on the area at any one time. This illustrates that residents as well as transients were involved in the fluctuations of composition.

Composition.—Complete trapping coverage of the study area was first accomplished during the summer quarter of 1953. Because of the intensive trapping effort during this period, it was assumed that all marten resident on the area at that time were captured. This assumption was substantiated in part by track evidence in the winter which indicated that all marten in an area were captured when subjected to intensive trapping effort. It is possible that marten residing on the edge of the area could be missed during any one trapping period as their ranges extend outside the area of trap influence. For this reason marten reported as lost from the area at this time may reappear in the captures at a later date. Other comparable trapping periods, from the standpoint of trap coverage and trapping effort, were the winter, summer, and fall quarters of 1954. Comparison of population composition at the end of each quarterly pe-

riod and fluctuations during these four quarters appears in Table 4 and discussion follows.

Of the twenty-three marten resident at the end of the summer 1953, one adult male and two juvenile males were last captured during the winter quarter of 1954. These disappearances did not occur until near the end of the quarter so that the immigration of one adult male, two juvenile males and one juvenile female raised the number of residents to twenty-seven during the winter. The composition of the adult residents was nine males and nine females at this population peak. Additional residents were seven juvenile males and two juvenile females.

TABLE 4.—*Composition and fluctuations of the resident population*

	SUMMER, 1953	WINTER, 1954			SUMMER, 1954			FALL, 1954		
	TOTAL*	GAIN	LOSS	TOTAL	GAIN	LOSS	TOTAL	GAIN	LOSS	TOTAL
Adult males	8	1	2	7(7)†	2	2	11‡(9)	0	0	11(9)
Adult females	9	0	1	8(8)	1	5	4(3)	0	1	3(2)
Juvenile males	5	2	3	4(3)	1	0	1(0)‡	0	1	0(0)
Juvenile females	1	1	1	1(1)	0	1	0(0)	0	0	0(0)

* Totals are the composition at the end of each quarter, while the gain and loss occurred during the quarter.

† Numbers in parentheses are marten remaining from 1953 population.

‡ The four males appearing as juveniles in Winter, 1954, are included as adults in Summer, 1954.

Further loss of the 1953 residents occurred during the summer of 1954 when five adult females, one yearling female and one yearling male were no longer captured. In addition, one yearling that became resident in the winter disappeared from the captures at this time. These losses were compensated in part by a gain of two adult males, one adult female and one juvenile male. Inasmuch as the compensation was not complete, only sixteen marten were resident on the area at the end of the summer in 1954 as compared to the twenty-three resident at the end of the summer in 1953. Although one adult male resident disappeared, there was total gain of four from 1953 to end of summer, 1954. This was the result of continued residence of two juvenile males from 1953 (now adults) and the ingress of three adult males into the area.

One adult female from the 1953 segment disappeared from the area during the fall quarter of 1954. The juvenile male, resident the previous quarter, also disappeared at this time. The population thus was composed of eleven adult males and three adult females at the end of the investigative period. Eleven (9 males and 2 females) of these fourteen marten remained from the twenty-three residents of 1953.

Summarizing this discussion of composition, there was an increase in the number of resident marten on the area during the winter quarter of 1954 from the number present at the end of summer 1953. After the population peak during

the winter, there was a decline throughout the summer and fall of 1954 even with the addition of new residents during the summer quarter. The result was a net loss of nine marten in the period between September, 1953 and December, 1954. The loss was largest in the adult female portion of the population. Some juveniles in 1953 became resident on the area and of these, two males remained for the rest of the investigative period. None of the 1954 juveniles remained on the area through October, 1954. If the 1954 juveniles had remained on the area in the same numbers as those from 1953, the net loss would have been but two marten for the entire period. Thus, juveniles and adult females were involved most in the population decline during 1954.

Dispersal.—Losses of marten from the area must have been through either emigration or death. The appearance of untagged adults on the study area apparently represents an emigration from another population. It is, therefore, possible that emigration from this population also occurred. Although evidence of such movements by adult residents was not obtained, three instances of juvenile dispersal were recorded.

Two juvenile males, first captured on the study area as transients in March of 1954, were later captured on Dutch Creek, distant about 6 miles. Both of these animals apparently were born off the study area and were captured as they passed through. One of these marten was recaptured in August, 1954, and the other in August, 1955. Another juvenile male, believed to have been born on the area, was captured twice on Anaconda Creek in August, 1954, and was recaptured outside the Park in October. The distance between the last capture location on the study area and the capture location outside the Park was approximately 25 miles. It was necessary for this marten to cross several large creeks and the North Fork of the Flathead River in this movement.

Population condition.—Direct evidence of mortality factors was not obtained; however, several indications of poor condition were noted in certain segments of the population. Adult female weights were significantly lower (1 per cent level) than those obtained from adult females in the nearby Whitefish Range, outside the Park. These weights are compared in Table 5. Furthermore, the mean weights of adult females were significantly lower (1 per cent level) than the mean weights of juvenile females after July 15, by which time adult size was attained (Table 5). Additional evidence that the adult female portion of

TABLE 5.—*Weights of female marten*

	MEAN (GRAMS)	NO. OF WEIGHTS	RANGE (GRAMS)	S.D.	S.E.
Adult—Whitefish Range	661	9	600-775	50.2	17.7
Adult—Glacier Nat'l. Park	581	19	475-675	52.5	12.4
Juveniles—Glacier Nat'l. Park	647	9	550-725	52.5	18.5

the population was in poor condition came from trap deaths. One juvenile female and one adult female died in traps in 1953 and 1954, respectively. Autopsy by the Fur Animal Disease Research Laboratory at Pullman, Washington, indicated that the juvenile female probably died of starvation with an accompanying anemia. Previous to the time of their deaths both animals were above the mean weight of adult females.

Three other deaths of adult females occurred in 1955 during live trapping of a dense population in the Whitefish Range. These females seemingly were in good condition when first observed in the traps. They soon became lethargic and listless while being handled, went into coma and died in the transport cages within a few hours. The rapid physical retrogression of these animals under stress was similar to the effects of "shock disease" in over-abundant populations of various other mammals (Christian, 1950). Although five deaths have occurred among females, no males have died in traps during this live trapping. The mechanics of this differential mortality are not known but it indicates that females are more subject to trap death than are males. The same may be true for mortality resulting from other causes.

Lowered reproduction or survival may be indicated by the change in the ratio of young to adult females between 1953 and 1954. In summer, 1953, eleven juveniles and five adult females (2.2:1) were captured while in summer, 1954, eleven juveniles and nine adult females (1.2:1) were captured.

Low weights, poor production of young and inability to survive unusual stress may be indications of crowding and food scarcity. The decline in the marten population was preceded by a decrease in the numbers of mice taken on two sample plots (Table 6). Since mice are important in the marten diet, this decrease may have been sufficient to cause a shortage of food and consequent reduction in carrying capacity.

The evidence discussed points to a period of overpopulation and subsequent

TABLE 6.—*Results of small mammal trapping*

SPECIES	SUMMER, 1953		FALL, 1953		SUMMER, 1954		FALL, 1954	
	PLOT I	PLOT II*	PLOT I	PLOT II	PLOT I	PLOT II	PLOT I	PLOT II
Microtus pennsylvanicus	8	—	6	3	7	1	1	0
Microtus longicaudus	1	—	1	9	0	10	0	2
Zapus princeps	1	—	0	0	1	0	0	0
Clethrionomys gapperi	2	—	14	53	2	3	11	27
Synaptomys borealis	0	—	1	0	0	0	0	0
Peromyscus maniculatus	0	—	0	5	0	4	0	4
Sorex sp.	0	—	2	0	2	14	6	0
Total	12	—	24	70	12	32	18	33
Combined total			94		44		51	

* Not trapped in summer of 1953.

expulsion or death of juveniles and adult females. These differential losses may be explained as follows.

Food requirements of these segments of the population should be proportionately greater than those of the adult male. Juveniles must meet the demands of growth and at the same time compete against adult marten with established foraging areas. This may place them in a less favorable position for survival. Energy requirements of adult females may be even more difficult to satisfy. Prenatal development, with birth of young about April; juvenile dependency, ending by August; and breeding season activities in July and August, may place excessive demands upon the food-gathering abilities of the adult female. This would be especially true during periods of food scarcity.

Population pressures apparently resulted in greater vulnerability to stress for adult females. These pressures also may have caused intraspecific strife with consequent dispersal or death of individuals.

Population density.—The number of marten present on the study area has been shown to vary with time. Therefore, the density of marten is also a variable factor. Densities during the winter and fall quarters of 1954 were calculated since they represented the high and low, respectively, in population numbers.

During the winter period, a maximum of twenty-seven marten were residing wholly or partially on the area but only eleven marten were living completely within the area boundaries. It is possible that all twenty-seven or only the eleven marten were on the area at one time. As the size of the trapped area was 6.2 square miles, the maximum density during the population peak was 4.4 marten per square mile and the minimum was 1.8 marten per square mile. Comparable densities for the low population during the fall quarter were 2.3 and 0.5 marten per square mile since fourteen marten had at least a part of their home range on the study area while only three were known to be living completely within the area boundaries.

SUMMARY

Information on home ranges and composition fluctuations of a marten population was obtained from a two and one-half year live trapping study in Glacier National Park, Montana.

Eleven home ranges, six of males and five of females, were enclosed within the boundaries of the six-square mile study area. The mean home range size of 0.92 square mile for males is significantly different from the mean of 0.27 square mile for the home ranges of females. Home ranges of adult marten of like sex showed a spatial distribution on the area. Resident marten tended to remain on the same home range for periods as long as 819 days with no seasonal movements observed. Some home range boundaries coincided with vegetative or topographic features.

The composition of the population was continually undergoing change through gain and loss of marten. The resident population initially increased in numbers from twenty-three in the summer of 1953 to twenty-seven in the

winter of 1954, and then declined to a low of fourteen in the fall of 1954. Juveniles and adult females were involved most in the population decline. Three juvenile male marten were known to have dispersed from the population but the means whereby adults were lost from the area was not discovered. Evidence discussed suggests a period of overpopulation with food as the limiting factor in the habitat. Population densities computed for the study period were subject to considerable variation.

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PANCREATIC WEIGHT AND HISTOLOGY IN THE WHITE WHALE

By W. B. Quay

The gross anatomy of the cetacean pancreas has been described in several species, and was examined early in the white whale or beluga, *Delphinapterus leucas*, by Watson and Young (1878-9). But data on the weight and especially on the histology of the pancreas in whales is scanty and is apparently lacking for the beluga. The histology of the pancreas of the beluga differs in several respects from that of the blue whale as described by Jacobsen (1941) and possesses features of basic interest.

I am grateful to W. T. Ward and L. J. Marshal of the Adanac Whale and Fish Products Company for the opportunity of dissecting fresh belugas, and to the Horace H. Rackham School of Graduate Studies, University of Michigan, for travel funds.

MATERIALS AND METHODS

This report is based upon 12 specimens harpooned and shot near the mouth of the Churchill River, Churchill, Manitoba, Canada, on July 6 and 7, 1954. The specimens were dissected by the author within one to six hours of death. Their data are presented in Table 1. The estimates of the age and body weights of the specimens are based upon the graphs in Vladykov's (1944) monograph correlating length with weight and age in Saint Lawrence River belugas.

Whole, fresh pancreas specimens from four of the whales were cut into from two to four pieces for weighing to the nearest 0.1 gm. Blocks of tissue, each about 1 cm. in diameter, were taken from three widely separated areas of each pancreas. The blocks from specimens 1 and 2 were fixed for over a year in standard Bouin's fluid, and those from specimens 3 to 12 were fixed for the

Table 1.—*Descriptive data, pancreas weights and alpha:beta cell ratios in pancreatic islets*

SPECIMEN NUMBER, SEX	LENGTH (FEET)	COLOR	BODY WGT. (ESTIMATE LBS.)	AGE (YEARS, ESTIMATE)	REPRODUCTION	PANCREAS WGTS. (GMS.)	PAN. WGT./ BODY WGT. (GMS.)	% ALPHA CELLS	% BETA CELLS
1. ♂	8	blue	500	2	—	230	.00101	70	30
2. ♂	8	blue	—	2	—	—	—	38	62
3. ♂	8½	—	—	2	—	—	—	47	53
4. ♂	8½	—	—	2	—	—	—	54	46
5. ♂	9	blue	—	2–3	—	—	—	49	51
6. ♀	—	—	—	—	2 embryos (51 & 57 gms.)	—	—	75	25
7. ♀	10½	white	—	3	no embryos	—	—	42	58
8. ♀	11	—	—	3–4	no embryos	—	—	3	97
9. ♂	11½	—	—	4	—	—	—	34	66
10. ♂	11½	white	1300	4	—	466	.00079	45	55
11. ♂	11½	white	1300	4	—	424	.00072	31	69
12. ♂	12½	white	1700	5+	—	561	.00073	37	63

same period of time in a Bouin's fluid in which 0.5 per cent trichloroacetic acid replaced the glacial acetic acid. Serial paraffin sections, 5–10 microns in thickness, were stained according to the following techniques: (1) chrome alum hematoxylin and phloxine (Gomori, 1941), (2) Gomori's modification of the azan technique (Gomori, 1941), and (3) the methenamine silver method for argentaffin cells (Lillie, 1954).

RESULTS

Weight.—The weight of the pancreas and its per cent of the body weight in four specimens is given in Table 1. Although the data are meager, an increase in actual pancreas weight and a decrease in relative pancreas weight with age is suggested. The data presented here are in harmony with the thesis demonstrated by Padour (1950) that generally in mammals as total body size increases the per cent of the volume represented by the pancreas decreases. For example, in the rabbit the pancreas is 0.106–0.171 per cent of the body weight (Jaffe, 1951), 100 times the per cent of the body weight represented by the beluga pancreas. In eight sperm whales weighing 26,251–51,695 kgms. the pancreas has been stated to weigh from 4 to 14 kgms. (.0001–.0004 per cent of the body weight); in three fin whales weighing 34,351–54,768 kgms. the pancreas weighed from 20 to 32 kgms. (.0004–.0008 per cent of the body weight); and in a blue whale weighing 109,930 kgms. the pancreas weighed 40 kgms. (.0004 per cent of the body weight) (Ohno and Fujino, 1952). Average weights of the pancreas in the lesser rorqual, *Balaenoptera acutorostrata,* (5.4 kgms.), killer whale, *Grampus rectipinna,* (3.5 kgms.), and beaked whale, *Berardius bairdi,* (5.0 kgms.) have been reported by Takaoka and others (1953), but the body weights of the specimens were not provided.

Histology.—Slides of pancreas from all of the specimens were entirely satisfactorily stained when the chrome alum hematoxylin and phloxine procedure was used. Since the best results were obtained by this method, the subsequent descriptions are based largely upon material stained by this method. The methenamine silver technique did not selectively stain any particular cells in the pancreas. The azan technique stained the granules of the alpha cells of the pancreatic islets orange to red and those of the beta cells paler orange. Unmodified pancreatic duct cells and similar cells within islets are nearly colorless after this technique. However, the distinguishing of cell types after the azan procedure sometimes proved to be difficult, owing perhaps to the type and length of fixation.

The pancreas of the beluga contains both exocrine and endocrine tissue. The exocrine pancreas of the beluga is characterized by the abundance of ducts and the rather uniform and large size of their cells. Intralobular and intercalated ducts are numerous and are composed of cuboidal, sometimes flattened, cells with nearly clear cytoplasm and large, oval nuclei. All of the ducts observed, even the smaller interlobar ducts, were composed of a single layer of these pale cuboidal or squamous cells. In several specimens, typical alpha cells stained with phloxine are present occasionally in the simple cuboidal epithelium of the

intra- and interlobular ducts (Plate I). Although over a dozen alpha cells were seen in the ducts, no beta cells were observed in similar locations.

The acini of the exocrine pancreas appear to be similar to those of other animals in staining characteristics and structure (Plate I). In many instances, small clumps of islet cells or single islet cells, usually alpha cells, are wedged in the sides or ends of exocrine acini.

The pancreatic islets, the endocrine portion of the pancreas of the beluga are of especial interest since islet distribution and size in this species differs from that described in the blue whale *(Balaenoptera musculus)* by Jacobsen (1941). Jacobsen stated that he could find no difference in the size or number of the islets in different parts of the pancreas in the blue whale, and that the average size and number of islets per cubic centimeter are less than in man and certain other mammals. In the beluga, there is marked regional variation in the number of islets present and in some blocks of pancreas they are absent. However, the material at hand is not sufficient to indicate whether the areas of islet abundance and scarcity are well defined or consistent anatomically.

Pancreatic islets in the beluga are usually intralobular in location. But in several specimens, interlobar islets were seen. Such islets are located within thick connective tissue septa separating lobes of exocrine tissue. The structure and location of the interlobar islets in the beluga are similar to those of the primary or first-formed islets in the rabbit, as recently reviewed and described by Bencosme (1955).

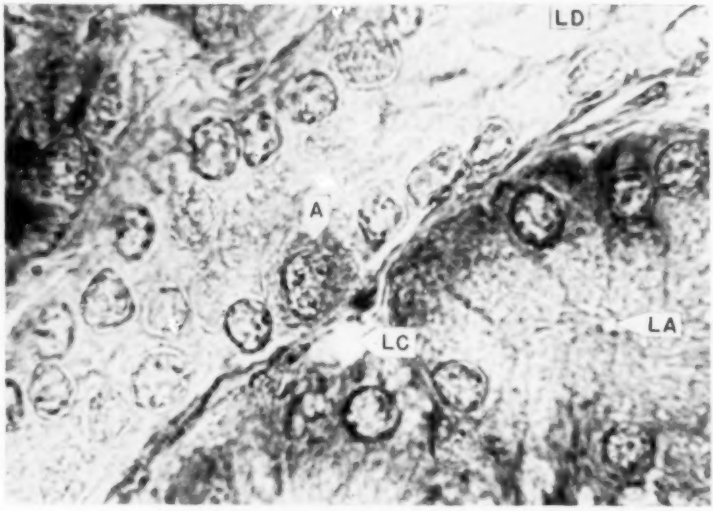

PLATE I

Small area from the pancreas of beluga specimen 2, stained with chrome alum hematoxylin and phloxine. *A*, alpha cell in the wall of a small duct; *LA*, lumen of an exocrine acinus; *LC*, lumen of a capillary; *LD*, lumen of the small duct. × 1550.

Variation in the diameter of the pancreatic islets in a number of mammalian species has been known for some time (Bargmann, 1939). In man and other mammals, as a rule, very small islets dominate in numbers and larger islets are progressively less common. Jacobsen (1941) measured 129 islets from a blue whale, 88 from a woman, and 176 from an ape. He found altogether only 3 islets

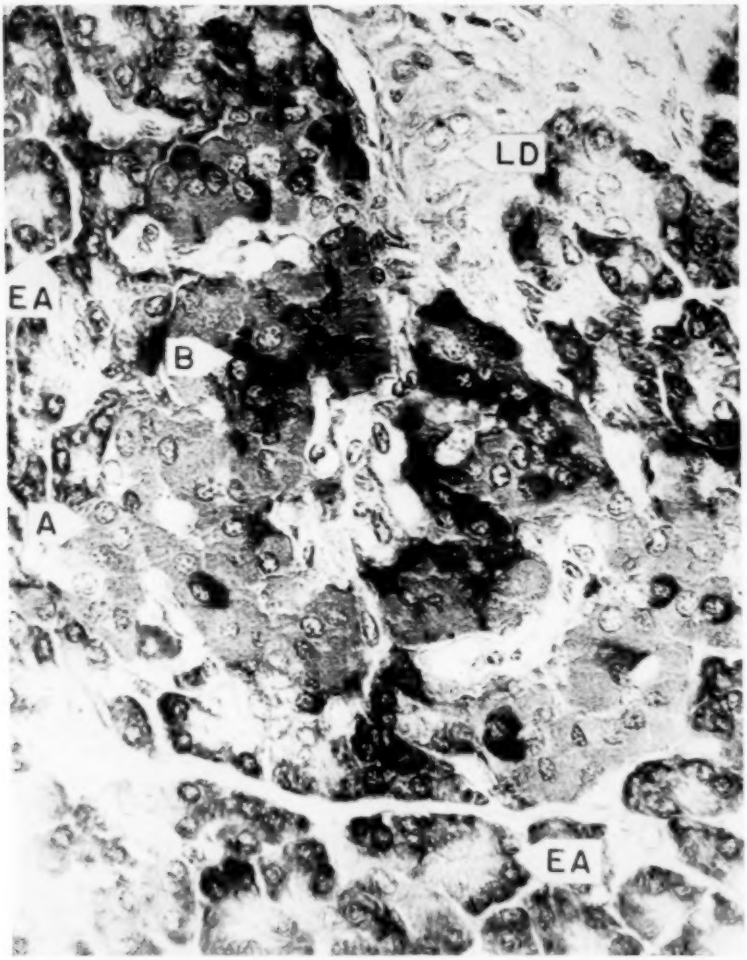

PLATE II

A typical pancreatic islet from beluga specimen 1, stained with chrome alum hematoxylin and phloxine. *A*, alpha cell; *B*, beta cell; *EA*, exocrine acini; *LD*, lumen of a small duct. × 610.

under 66 microns in maximum diameter. Since he was apparently utilizing only slides stained with hematoxylin and eosin, and since his data for human islet diameter are at such variance with those of other authors (Bargmann, 1939), it seems likely that the very small islets were underestimated. Measurement of pancreatic islets from different areas in the 12 beluga specimens are presented in Table 2. The numerous, scattered individual islet cells and small islets under 35.5 microns in diameter are omitted from this table. The numerical pattern and marked individual variation shown in the islet measurements are similar to the pattern and variation found in other mammals (see table, Bargmann, 1939). For the blue whale, Jacobsen (1941) records no islets over 185 microns in maximum diameter. Since in all beluga specimens, islets over 185 microns in maximum diameter are present, Jacobsen's conclusion that the islets are

TABLE 2.—*Percentages of pancreatic islets within each size class, according to maximum islet length (A) and minimum islet width (B). Specimen numbers correspond to those used in Table 1. N = number of islets measured and greater than 35.5 microns in length (A) or width (B)*

SPECIMEN NUMBER, SEX		SIZE CLASSES (MEASUREMENTS IN MICRONS)																
		N	36-65	66-95	96-125	126-155	156-185	186-215	216-245	246-275	276-305	306-335	336-365	366-395	396-425	426-455	456-485
1♂	A	105	32.4	25.7	12.4	12.4	4.8	5.7	2.8	0	3.8						
	B	73	58.9	23.3	16.4	1.4											
2♂	A	28	42.9	35.7	7.1	3.6	7.1	3.6									
	B	22	77.3	22.7													
3♂	A	34	41.2	20.6	29.4	5.9	0	2.9									
	B	24	75.0	16.7	8.3												
4♂	A	51	35.3	17.6	15.7	9.8	9.8	5.9	0	3.9	2.0						
	B	42	50.0	30.9	14.3	2.4	2.4										
5♂	A	57	15.8	17.5	19.3	17.5	10.5	1.8	5.3	7.0	1.8	1.8	0	0	0	0	1.7
	B	51	51.0	25.5	13.7	7.8	2.0										
6♀	A	75	44.0	28.0	10.7	8.0	6.7	1.3	1.3								
	B	56	60.7	30.4	5.3	3.6											
7♀	A	31	35.5	35.5	12.9	6.5	3.2	3.2	0	3.2							
	B	22	77.3	9.1	13.6												
8♀	A	67	23.9	22.4	11.9	16.4	8.9	3.0	0	1.5	4.5	1.5	1.5	1.5	1.5	0	1.5
	B	57	45.6	29.8	15.8	7.0	1.8										
9♂	A	62	30.7	25.8	8.1	8.1	6.4	8.1	0	1.6	6.4	0	4.8				
	B	53	50.9	28.3	11.3	7.6	0	0	1.9								
10♂	A	86	52.3	38.4	5.8	1.2	0	0	0	1.2	1.1						
	B	56	78.6	14.3	7.1												
11♂	A	35	42.9	20.0	20.0	8.6	2.8	5.7									
	B	21	95.2	0	4.8												
12♂	A	48	27.1	25.0	18.7	14.6	4.2	6.2	0	4.2							
	B	39	48.7	38.5	7.7	2.5	2.5										
Means	A		35.3	26.0	14.3	9.4	5.4	4.0	0.8	1.9	1.6	0.3	0.5	0.1	0.1	0	0.3
	B		64.1	22.4	9.9	2.7	0.7	0	0.2								

small in the blue whale appears significant. In two belugas, islets over 456 microns in maximum diameter are recorded (Table 2); this is approximately the maximum diameter also for the human islets (Bargmann, 1939). In a porpoise, *Steno rostratus*, Neuville (1926, 1936) found islets measuring from 25 × 25 to 170 × 225 microns.

The cell types found in the islets of the cetacean pancreas and the variation in cell number, location, and structure apparently have never been studied. By means of Gomori's chrome alum hematoxylin and phloxine technique, three cell types can be distinguished in the beluga islets: (1) alpha cells stained red, (2) beta cells stained blue, and (3) chromophobes stained very slightly if at all and generally indistinguishable from duct cells. Each islet usually contains both alpha and beta cells, but in several specimens pure beta cell islets or pure alpha cell islets of greater than average size are seen. As a general rule, the alpha cells are peripherally located in the islets and the beta cells are centrally located (Plate II). This pattern also typifies most other mammals, except the horse and possibly certain artiodactyls (Thomas, 1937). Differential counts of alpha and beta cells in numerous islets of each of the 12 whales show extreme individual variation in the relative numbers of the cells of the two types (Table 1). Although beta cells usually outnumber alpha cells, in three specimens the reverse is true.

The nuclei of the alpha and beta cells are similar in size and morphology and are usually large and oval, but pyknotic nuclei are sometimes seen in cells of both types.

The islets in the beluga pancreas display numerous capillaries, as is true also for the islets of other mammals. Neuro-insular complexes have not been observed in the beluga pancreas.

DISCUSSION

The beta cells of the pancreatic islets are now generally accepted as the source of insulin in the mammal. Since insulin is commercially obtainable only by extraction of pancreatic tissue, the insulin content of the pancreas in large cetaceans has been the subject of repeated study (Yamagawa and Nishimura, 1926; Yamagawa and Yasaka, 1926; Jacobsen, 1935 and 1941; Jorpes, 1950; and Takaoka *et al.*, 1953). From the data of these authors, the insulin content of the cetacean pancreas appears to be variable and frequently relatively low. Correlations between insulin content and taxonomic groups are still obscure. The histological evidence presented here from the beluga indicates that the insulin content of the pancreas may be fairly high, in contrast with that of the blue whale, in which both islet tissue and insulin are known to be present at relatively low levels (Jacobsen, 1941). However, the beluga and other cetaceans would not appear to be commercially feasible sources of insulin, except in the case of greatly increased demand for insulin or reduced availability from meat-packing industries based on cattle and other domestic species (see Jorpes, 1950).

SUMMARY

The weight of the pancreas in four white whales or belugas ranged from 230 grams (.0010 per cent of the body weight) in a specimen estimated to be 2 years old to 561 gms. (.0007 per cent of the body weight) in a specimen estimated to be over 5 years old. The histology of the pancreas was studied in 12 specimens and demonstrates that: (1) the exocrine pancreas has a high content of duct cells; (2) the pancreatic islets are numerous and large, but vary greatly in distribution, size, shape and cell content; (3) the islets attain a larger size and have a more irregular distribution in this species than in the blue whale; (4) alpha and beta cells are numerous and are stained by phloxine and chrome alum hematoxylin respectively; (5) within each islet, alpha cells are generally peripheral and beta cells central in position; (6) beta cells usually outnumber alpha cells in the pancreas, but extreme individual variation exists; (7) chromophobic or nearly unstained islet cells, resembling duct cells, are present but not common.

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Dept. of Zoology, Univ. of California, Berkeley 4. Received April 12, 1956.

FIELD OBSERVATIONS ON *TAMIAS STRIATUS* IN WISCONSIN

BY JOSEPH A. PANUSKA AND NELSON J. WADE

Observations and collecting of *Tamias striatus* (L.) in the area of Waupaca, Wisconsin during the summers of 1952 through 1955 have yielded data relevant to sex ratios and natural history. The paucity of reports involving large numbers of this chipmunk prompt us to present this communication—drawn from field records of more intensive research on the hibernation of this species.

Most captured chipmunks appeared closely related to *T. s. griseus* Mearns. Some resembled *T. s. lysteri* (Richardson), and others appeared to be intermediates. The ranges of these two subspecies have long been known to be contiguous in this part of central Wisconsin (Howell, 1929). In such mammalian populations we favor the viewpoint of Burt (1954) and others and will not attempt subspecific designation. No *Eutamias* were found in the area of Waupaca during the present study.

MATERIALS AND METHODS

At first wooden, sliding-door traps and later "Havahart" live traps were employed. Weights were measured on a "Hansen" diet spring-scale. Field weights were taken before captured animals were fed or watered. In general, captured animals were without food or water for several hours prior to the initial weighing. Subsequent weights were made on animals which had access to Purina Laboratory Chow and water *ad lib*. Glass drinking bottles served for the measurement of water consumption, and animals were marked by toe clipping.

The sites, all within a few miles of Rainbow Lake (Waupaca County), can be differentiated into three areas: 1) Government Island, an uninhabited, tree-covered island; 2) wooded shore areas fairly close to human dwellings; and 3) a large vegetable garden, the "Hacker" site. At Sites 1 and 2 traps were usually placed near burrow entrances and shifted as burrows were apparently trapped out. At Site 3 traps were simply placed in random fashion throughout the garden area. The trap-lines were examined daily at about 9 AM and 5 PM.

OBSERVATIONS

Capture.—In every instance observed, chipmunks approached the traps with considerable caution. Varying behavior was noted when animals approached a trap the second time, after having once escaped. In some cases no additional hesitancy was manifest. In one case, an animal dwelling in a small burrow system dug under a trap instead of entering it; in this manner it was able to obtain corn resting on the mesh floor. When all of the corn thus available was obtained, the trap was entered in pursuit of the last few kernels. Chipmunks were also seen digging under baited traps containing captive wild mice.

In practically all cases there was a violent reaction to initial capture and subsequent caging. However, none refused to eat when fed and only one died from what seemed to be over-excitement. About 10 per cent died en route to St. Louis; these were generally smaller animals.

Association with other animals in common cages proved disturbing to most individuals at first. Several times one of the larger animals clearly demonstrated dominance over cage mates. This was first observed visually. Later, when younger members of such communities were isolated and given their own food, extra weight increases by these individuals confirmed the observation. A sex determinant in dominance was not evident.

Although most animals eventually settled down to a cage existence, for the most part they never became accustomed to the approach of man or other large animals and regularly exhibited the same nervous reactions.

Sex Ratios.—The sex ratios are given in Table 1. With reference to length of trapping time, only the Hacker site showed any significant male–female ratio difference. This site differed from Sites 1 and 2 in that only those animals which had traveled relatively far from their burrows to approach the garden were trapped.

The home ranges proposed by Burt (1940), 1.04–2.04 acres; Blair (1942), 2.15–2.31 acres; Manville (1949), 0.19–0.43 acres; and Yerger (1953), 0.26–0.37 acres, are not contradicted by the 1954 capture of 75 animals at the Hacker site. A forest began approximately 30 feet from the edge of the garden. An especially dense population of chipmunks at the edge of this forest would allow for even the small home ranges of Manville and Yerger. However, it must be considered that the attraction of the garden food-supply would tend to extend the home range if this were necessary.

Males were captured earlier at the Hacker site as is indicated by the following data: June 24–30 (1954), 16 animals, 80 per cent males; July 1–7, 54 animals, 40 per cent males; July 8–16, 4 animals, no males. This pattern was not followed at the other sites where traps were placed close to burrow entrances. The general trapping totals for all sites according to time were as follows: June 17–23 (1954), 19 animals, 31.6 per cent males; June 24–30, 49 animals, 46.9 per cent males; July 1–7, 55 animals, 40 per cent males; July 8–16, 32 animals, 50 per cent males; July 17–23, 8 animals, 37.5 per cent males; July 24–31, 7 animals, 42.9 per cent males. The suggestions of Burt, Blair, Manville, and Yerger, that the home range of males exceeds that of females, might explain the incidence of males captured at Hacker's.

Table 2 summarizes the sex ratios proposed by past investigations of the eastern chipmunk as compared with the present study. The significance of such over-all ratios is questionable,

TABLE 1.—*Field weights and weight gains in grams, and sex ratios according to sites and years*[*]

	1952	1953	1954				1955
			SITE 1	SITE 2	SITE 3	TOTALS	
Total animals	20	38	39	55	75	169	44
Per cent male	45.0	52.6	41.0	43.6	45.4	43.5	56.8
Per cent female	55.0	47.4	59.0	56.4	54.7	56.5	43.2
Average field weight	—	—	85.3	87.5	84.0	85.4	—
High field weight	—	—	122	125	145	—	—
Low field weight	—	—	36	53	65	—	—
Average weight Sept. 8	—	—	117.2	116.5	110.3	113.6	122.8
High weight Sept. 8	—	—	131	146	150	—	145
Low weight Sept. 8	—	—	94	97	75	—	94
Average weight gain, capture until Sept.	—	—	31.9	29.0	27.3	28.2	—

[*] Total animals studied, 271; per cent male, 44.9; per cent female, 55.1; average male field weight, 85.6; average female field weight, 85.2.

for several reasons. First, different populations are involved; perhaps some of these populations are growing and some are not. This factor should affect the ratios. Second, although the general trapping periods are the spring and summer, one must remember that nursing periods will affect these ratios. A third factor that might affect such experimental sex ratios is any difference that exists between the home range of the males and females of a particular species. It seems that unless a technique is employed which involves the complete trapping of a specific area, rather than partial trapping, the sex with the larger home range would tend to predominate in the total capture. Hence the sex ratio picture would not be completely accurate.

TABLE 2.—*Sex ratios reported by various investigators*

	YEAR PUBLISHED	NUMBER OF ANIMALS	PER CENT MALE	PER CENT FEMALE
Burt	1940	106	60	40
Blair	1942	154	51.3	48.7
Smith	1942	60	45	55
Linduska	1950	333	40	60
Yerger	1955	202	43.6	56.4
Present Study		271	44.9	55.1

The factors of trapping time and home range would seem to favor the males percentagewise, but nevertheless, the recent figures of Linduska (1950), Yerger (1955), and the present study afford a consistent picture of higher female percentages. These three investigations were carried out in Michigan, New York, and Wisconsin, respectively.

Water Consumption.—One day usually passed before chipmunks learned to recognize and use drinking tubes. One animal, failing to learn this technique for a three-week period prior to shipping, had to be provided with another water source.

Water loss from the bottles due to evaporation was only a few ml. a week. Undoubtedly there was some loss due to dripping, although an attempt was made to keep this at a minimum by wiring the drinking bottles to steady cages, thereby preventing shaking. Most animals lost little water while drinking.

The average daily water intake was 33.4 ml. This compares favorably with a check made in the laboratory in St. Louis where the average intake at a room temperature of 75–80° F. was 29.2 ml. These figures seem high, but the large water intake of these caged animals has proved to be a highly constant factor. Perhaps this high water consumption can be related to the fact that the animals inhabited an area which is marked by numerous small lakes, usually providing easy access to water. Indeed, many burrows were seen within a few feet of the shore line. On Government Island, for example, frequent trapping expeditions left the investigators with the impression that the edge of the island, except in one marshy region, was significantly more heavily populated with chipmunks than the interior of the island.

Water intake diminishes considerably when an animal is kept in an artificial burrow-box. Such burrow-boxes have been described in a previous paper (Panuska and Wade, 1956). This observation affords a clue concerning the complexity of influences affecting water consumption records of a caged animal.

Weights.—Field weights and subsequent weights prior to any experimentation are given in Table 1. The September 8 weight was taken about one month after the animals had arrived in St. Louis.

Weight gains after short periods of captivity are indicated in Table 3. The same table shows weight decreases subsequent to deprivation of food and water. Such large fluctuations imply that the initial weight gains are only indicative of an unusually large consumption of food and water; there is no metabolic significance. These changes also serve to remind investigators that the field weights of small mammals require careful interpretation.

The September gains (Table 1), which were more stable, are apparently due to a combination of factors—the abundance of food, the lack of natural exercise resulting from confinement, and in some cases a definite manifestation of growth. Three chipmunks may serve as examples of this last suggestion. These animals weighed 55, 54 and 54 g. in the field; in September they weighed 129, 115, and 103 g. respectively.

Health.—Frequent rapid somersaulting by several animals seemed to indicate, possibly, an inner ear disease. One animal, which had suffered the loss of about one-half of its hair, was found. All other animals when captured appeared to be in good health. Marked infestations of external parasites were never noted. Intestinal examinations often revealed roundworms and tapeworms.

TABLE 3.—*Weight gains and losses*

Weight gains immediately after capture; averages of eight animals
Field Weight, July 18: 85.6 grams

DAYS OF CAPTIVITY	WEIGHT	PER CENT GAIN OVER FIELD WEIGHT
One	95.5	11.6
Two	98.5	15.1
Three	100.1	16.1
Four	102.1	19.4
Five	102.8	20.0
Six	105.1	22.8

Weight loss after deprivation of food and water for 24 hours; averages of six animals

Weight on July 26, 8 AM: 106.3
(Food and water removed after weighing.)
Weight on July 27, 8 AM: 90.3
(Food and water returned after weighing.)
Weight on July 27, 10 AM: 99.2
Weight on July 27, 5 PM: 108.8
Weight on July 28, 8 AM: 106.0

Mating.—Some males with descended testes were captured in late June; very few were found in late July or early August. On microscopic examination, undescended testes never demonstrated spermatogenesis.

Pregnant females were not found in late June or early July. Only three such females were captured in late July or early August. These animals had litters of 5, 5, and 4 young. The young of two litters died within a few days after birth; some were eaten by the mother. The mother of the third litter nursed the young for 24 days (August 3–27). This nursing period was insufficient to render the young independent of the mother. At 24 days the individuals comprising this litter had well-developed stripes, but the eyes had not yet opened, and the animals were quite incapable of foraging for themselves. Whether or not their development was slow because of a diet deficiency of the mother or from some other cause is difficult to determine. The average measurements of four members of this litter, after fixation in 10 per cent formalin, were as follows: weight, 14.1 g.; total length, 113 mm.; tail, 25.6 mm.; left hind foot, 15.2 mm. The long nursing of chipmunks is discussed extensively by Allen (1938).

Neither mating nor pregnancies in captivity were noted. Opportunities for mating were afforded the animals from the time of capture until mid-September, rarely during the winter, and during their second summer in St. Louis.

The late breeding season of a part of the population raises problems pertinent to the breeding cycle which remain unsolved for this species. Yerger (1955) has neatly summarized the present status of this question.

Possible Aestivation.—The weather was hot and dry during the last two weeks of July, 1954. The disappearance of chipmunks from the local scene was notable. Although traps were placed in new and promising areas at this time, the totals captured dropped sharply. These totals are listed in the section concerning sex ratios.

Several occupied burrows that had previously been selected for study from blinds and had never been trapped also failed to show activity during this warm period.

SUMMARY

Summer field observations on *Tamias striatus* (L.) at Waupaca, Wisconsin, have been noted with special reference to reaction to capture, sex ratios, water consumption, field weights and weight changes, mating periods, and possible aestivation.

Sex ratios differed from year to year; the over-all average for 271 animals was 44.9 per cent male and 55.1 per cent female. The average daily water consumption of caged animals, measured by drinking tubes, was 33.4 ml., and the average field weight was 85.4 grams. 11.6 per cent weight increases were noted after one day of captivity, 22.8 per cent after six days of captivity. There were great fluctuations in weight depending on the presence or absence of food.

Much investigation remains to be done on life history studies of the eastern chipmunk. Their social activities especially present a challenging enigma.

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Department of Biology, St. Louis University, St. Louis, Missouri. *Received April 19, 1956.*

THE WOODRATS OF THE EASTERN UNITED STATES

By Albert Schwartz and Eugene P. Odum

Although Goldman in 1910 considered *Neotoma floridana* (Ord) and *N. pennsylvanica* Stone (= *N. magister* Baird) as being quite distinct species (he separated them by the remaining members of the subgenus *Neotoma* as understood by him), some mammalogists in recent years have suggested that the two be considered conspecific. Burt and Barkalow (1942) indicated that separation into two species was unjustified on the basis of the shape of the baculum. Recent field guides and manuals (Burt and Grossenheider, 1952; Palmer, 1954) have tended to lump the two species together. It is the purpose of the present paper to review the distribution and characteristics of eastern woodrats, and to present evidence for the relegation of the name *N. magister* to subspecific status under *N. floridana*. New material obtained by the authors from the southern Appalachians, where the two forms meet, has been helpful in clarifying the situation.

To assess critically the differences in eastern woodrats we have examined specimens of all six populations which are currently named, that is, *magister, floridana, illinoensis, haematoreia, rubida* and *smalli*. We wish to extend our sincere thanks to the following curators who have made the necessary loans. Abbreviations used in the present paper are listed. George G. Goodwin (American Museum of Natural History); Frederick A. Ulmer, Jr. (Academy of Natural Sciences of Philadelphia); Viola S. Schantz (Biological Surveys Collection, U. S. Fish and Wildlife Service—BSC); J. Kenneth Doutt (Carnegie Museum); Colin C. Sanborn (Chicago Natural History Museum); W. Gene Frum; Donald W. Hoffmeister (University of Illinois Natural History Museum); Arthur Stupka (Great Smoky Mountains National Park—GSMNP); Barbara Lawrence (Museum of Comparative Zoology); Randolph L. Peterson (Royal Ontario Museum of Zoology); William H. Burt (Museum of Zoology, University of Michigan); David H. Johnson and Charles O. Handley, Jr. (United States National Museum—USNM). We have also utilized specimens in the Charleston Museum and the University of Georgia collections, as well as those in the collection of the senior author (AS).

DISTRIBUTION

The distribution of eastern woodrats is shown in Fig. 1. It seems likely that *Neotoma* invaded the eastern United States from the southwest (where the subfamily is well represented), with one segment moving north along the Appalachian Plateau and another along the Coastal Plain. The present range is conspicuously Y-shaped with an extensive hiatus in the Piedmont of Georgia and South Carolina where woodrats have never been taken. There are a number of birds (Swainson's warbler, parula warbler, song sparrow, for example) and a few other mammals *(Synaptomys, Condylura)* which exhibit a "split range" of this sort (i.e., have representatives in the mountains and Coastal Plain but

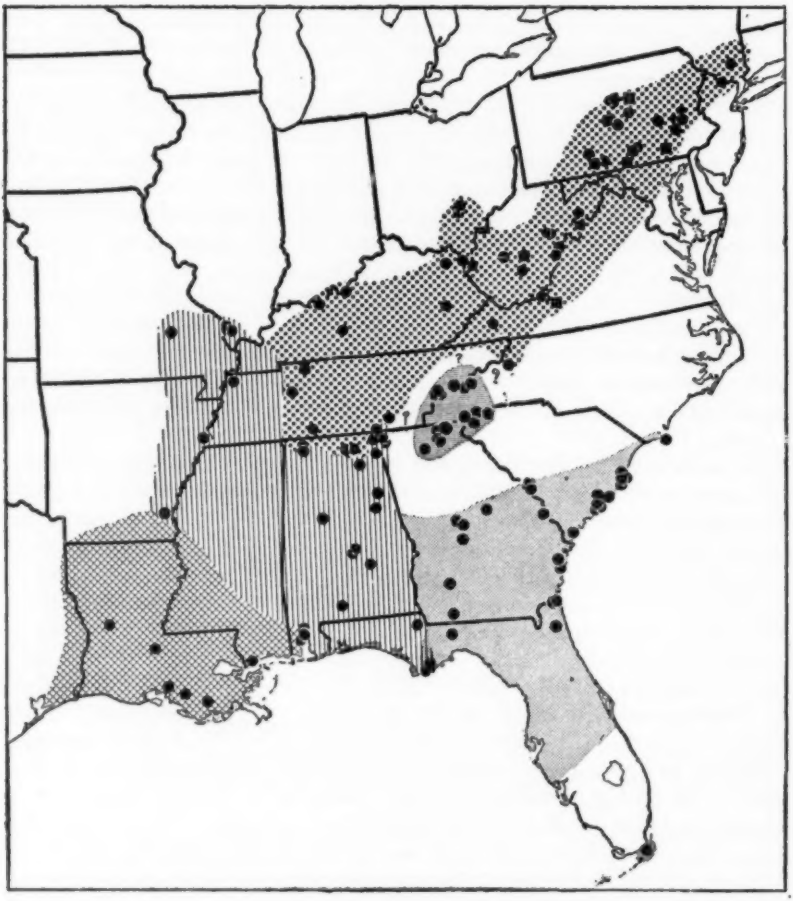

FIG. 1.—Distribution of the six subspecies of eastern woodrats, *Neotoma floridana*. The hiatus between *haematoreia* and *floridana* is a real one but the gap between *magister* and *haematoreia* in Tennessee and North Carolina is not intended to indicate a complete absence of animals but rather a lack of knowledge of subspecies present. Dark circles are localities from which specimens were actually examined.

not in the intervening Piedmont). However, in the case of *Neotoma*, the mountain and Coastal Plain populations are well connected through the broad stem of the "Y."

The Tennessee River is the currently recognized boundary line between *magister* and the five *floridana* populations. The present distributional pattern certainly provides no reason to suspect that this river would be an isolating factor at the species level any more than would various other large rivers. So far as we have observed, there are no ecological isolating mechanisms. Woodrats throughout their eastern range are adaptable to various habitats, living in caves and rock slides where available in the mountains, and in woods, swamps, and especially deserted buildings in the Coastal Plain. It remains for a study of the morphology to reveal whether there might have been sufficient isolation in the past to result in more than one species.

MEASUREMENTS

Standard measurements of the six populations of eastern *Neotoma* are summarized in Table 1. Only specimens judged to be adult are included in these data. While males averaged slightly larger in certain measurements, differences between the sexes proved not to be statistically significant ($p>0.05$) when *t*-values were computed for body size and skull length in the largest series available (i.e., the northern *magister* and *floridana* populations). Four of the most critical measurements are compared by means of Dice-Leraas graphs in Fig. 2. Since *magister* has a much greater north-south range than any of the *floridana* populations, and especially since there are more specimens available from the northern part of the range of *magister*, we have separated northern (West Virginia, Ohio and north) from southern (Kentucky, Virginia and south) specimens in Fig. 2. Otherwise, average measurements of *magister*, when taken as a unit, are heavily biased in favor of the larger northern individuals.

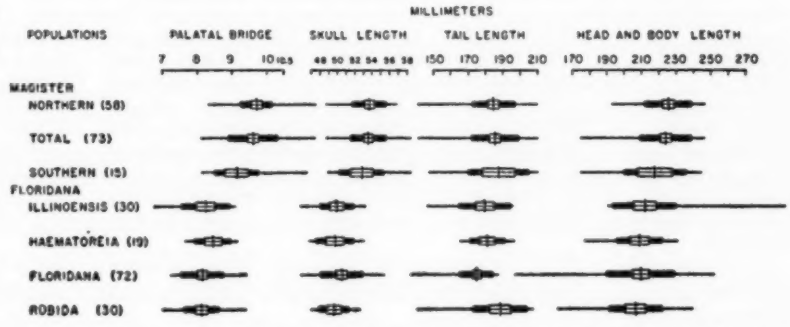

FIG. 2.—Dice-Leraas graphs of four key measurements of five populations of eastern *Neotoma*. Black bars show one standard deviation on each side of the mean while hollow rectangles show twice the standard error on each side of the mean.

As may be seen from Fig. 2 and Table 1, body size exhibits a north-south cline such as is common to many warm-blooded vertebrates; size changes gradually from north to south with no evident "break" anywhere along the line. Most of the other measurements exhibit the same pattern. However, certain structures in the palatine region of the skull show relatively more marked differences when *magister* populations are compared with *floridana*. The width of the palatine bridge is as extreme in this regard as any other standard measurement. Even in this case, as shown in Fig. 2, the southern individuals of *magister* are clearly intermediate between northern *magister* and *floridana*. Unfortunately, we do not have enough specimens from both sides of the Tennessee river to make quantitative comparison of populations which are actually living close together. In any event the order of magnitude of difference appears to us to be of a subspecific rather than a specific nature.

In most cases *magister* can be separated from the rest of eastern woodrats by skull characters which are more qualitative than quantitative. As originally pointed out by Goldman (1910) there are two features that seem clear-cut. Goldman stated that the interpterygoid fossa is very large, broadly excavated, and rounded anteriorly in *floridana*, and is rounded anteriorly but narrower in *magister*. This character will separate most skulls examined of the two forms, despite its qualitative nature. The interpterygoid fossa is much narrower in *magister* than in *floridana*, due principally to the closer approximation of the hamuli of the pterygoids. Secondly, the presphenoid is usually strap-shaped in *magister*, with consequent reduction of the extent of the sphenopalatine vacuities, which are usually narrow and slit-like. In *floridana* the presphenoid is usually constricted and almost triangular, and the sphenopalatine vacuities

TABLE 1.—*External and cranial measurements of the six eastern subspecies of Neotoma floridana*

Measurement, mm.	*N. f. magister* (73)	*N. f. magister* northern (58)*	*N. f. magister* southern (15)†	*N. f. illinoensis* (30)
Total length	410.3 (355–477)	410.5 (355–447)	409.5 (365–444)	390.8 (350–490)
Head and body	224.3 (175–247)	225.3 (193–247)	220.9 (175–245)	211.9 (190–294)
Tail	186.0 (147–210)	185.4 (160–210)	188.5 (147–210)	179.9 (146–195)
Hind foot	42.3 (33–50)	42.6 (33–50)	41.2 (38–46)	37.3 (28–41)
Greatest length	53.5 (48.6–58.3)	53.6 (48.6–56.8)	52.6 (48.7–58.3)	49.8 (45.5–53.0)
Condylobasal length	50.4 (44.5–54.9)	50.7 (44.5–54.2)	49.5 (44.6–54.9)	46.2 (42.3–50.6)
Zygomatic breadth	26.9 (23.2–29.2)	27.0 (23.2–29.2)	26.5 (23.9–29.2)	24.7 (22.6–26.6)
Length of nasals	21.0 (18.2–23.2)	21.1 (18.2–23.1)	20.7 (18.4–23.2)	19.3 (17.5–21.1)
Interorbital breadth	6.7 (6.1–7.4)	6.7 (6.2–7.4)	6.8 (6.1–7.4)	6.6 (5.7–7.4)
Length of palatine foramina	10.8 (9.0–12.6)	10.8 (9.0–11.9)	11.0 (9.0–12.6)	9.5 (8.2–10.8)
Palatal bridge	9.6 (8.1–11.4)	9.7 (8.3–11.4)	9.1 (8.1–10.2)	8.2 (6.7–9.1)
Upper molar tooth row	9.3 (8.3–10.0)	9.3 (8.4–10.0)	9.2 (8.3–10.0)	9.0 (8.2–9.6)

* West Virginia and Ohio northward.

are ovoid and broader than in *magister*. The nature of the presphenoid and the extent and shape of the sphenopalatine vacuities are characteristic of the two forms; this character will distinguish between the skulls of these rats in most cases. However, specimens of *magister* with narrow or slightly constricted presphenoids resemble skulls of *floridana* with broader and less constricted presphenoids, and the condition typical of *magister* grades imperceptibly into the condition typical of *floridana*. Another of Goldman's characters, the posterior extension of the ascending branch of the premaxilla beyond the nasals, shows the same situation. In *magister* the ascending branches terminate closely behind the posterior end of the nasals, while in *floridana* the ascending branches extend for several millimeters posterior to the nasal border. However, this condition is not completely diagnostic, since we have examined specimens of *magister* with long posterior projections of the premaxillae and specimens of *floridana* with short projections ending close to the posterior border of the nasals.

PELAGE CHARACTERISTICS

As in the case of most measurements, pelage characters also intergrade between *magister* and the more northern races of *floridana*. Thus, West Virginia specimens (*magister*) have a distinctly bicolor tail as compared with southern Georgia or Florida specimens (*floridana*), but animals from intermediate areas (*haematoreia*) show all degrees of variation between bicolor and unicolor tails.

From standard measurements and skull features alone (Fig. 2) we might conclude that we have one species and two well-marked subspecies. However, since the described races of *floridana* can be distinguished by pelage characters it seems desirable to consider that we have one species and six subspecies.

TABLE 1.—*Continued*

	N. f. haematoreia (19)	*N. f. floridana* (72)	*N. f. rubida* (30)	*N. f. smalli* (10)
Total length	387.6 (350–413)	382.6 (310–432)	393.5 (354–442)	372.3 (354–399)
Head and body	208.4 (177–231)	208.8 (136–252)	206.2 (161–239)	198.9 (181–219)
Tail	179.3 (165–196)	173.2 (136–187)	186.7 (140–207)	171.4 (161–180)
Hind foot	38.6 (35–42)	37.8 (28–42)	38.9 (28–44)	37.4 (36–40)
Greatest length	49.4 (46.6–52.9)	50.3 (45.6–55.2)	49.3 (46.8–52.4)	49.6 (47.2–52.2)
Condylobasal length	46.4 (43.7–50.2)	47.0 (42.4–52.1)	46.5 (42.7–50.3)	46.4 (44.4–48.8)
Zygomatic breadth	25.6 (23.5–26.8)	25.8 (23.3–28.9)	25.2 (22.4–28.0)	25.2 (24.1–26.4)
Length of nasals	18.5 (13.2–21.1)	19.3 (17.1–22.6)	19.1 (13.5–21.4)	19.2 (17.7–20.1)
Interorbital breadth	6.7 (6.2–7.6)	6.5 (5.7–7.1)	6.4 (5.8–7.0)	6.7 (6.3–7.2)
Length of palatine foramina	9.6 (8.0–10.6)	9.9 (8.4–11.3)	9.9 (9.4–10.7)	9.8 (8.8–10.8)
Palatal bridge	8.4 (7.6–9.1)	8.1 (7.2–9.4)	8.1 (7.0–9.4)	8.2 (7.7–8.6)
Upper molar tooth row	8.9 (8.2–9.6)	8.9 (8.0–9.7)	9.1 (8.5–9.8)	8.9 (8.4–9.3)

† Virginia, Kentucky, Tennessee and northern Alabama.

Of the five described races of the *floridana* group we do not need to consider *smalli*, recently described in detail by Sherman (1955), since it is an insular race of very local distribution. Since coloration is the only basis for the separation of the other four races it may be pertinent to describe the coloration in fresh pelage (late fall or early winter) of a typical individual of each race. The coloration of each subspecies is quite variable; Goldman (*op. cit.*: 12) has pointed out that the new coat is generally grayer and brighter than the old one, that it becomes duller and browner in advanced stages of wear, and that very old individuals often become rusty brownish in worn pelage. Such variation makes comparison of individuals with fresh pelage mandatory; comparison of series with pelage in various stages of wear and molt is a bewildering and unsatisfactory procedure. Since sexual differences in color appear to be minor, the general adult condition is considered.

A typical specimen, adult, and in fresh pelage, of each of these four subspecies may be described as follows.

1) *Neotoma f. floridana* (AS 2739), from Crooked River State Park, Camden Co., Georgia, taken November 29, 1953. Dorsal coloration generally dark with mid-dorsal band moderately well defined and black-tipped hairs prominent. Sides and ground color of mid-dorsal band Pinkish Buff (all capitalized color names from Ridgway, 1912); rump slightly darker (Light Pinkish Cinnamon). Crown Pinkish Buff, overlaid sparingly with black. Feet white. Belly white, fur gray basally on sides but not on throat or mid-ventral region.

2) *Neotoma f. haematoreia* (GSMNP 379), from Tremont C.C.C. Camp, Blount Co., Tennessee, taken October 7, 1950. Dorsal coloration generally dark with mid-dorsal band very well defined and black-tipped hairs prominent. Sides and ground color of mid-dorsal band Cinnamon-Buff; rump Cinnamon-Buff. Crown and head lighter (Pinkish Buff) and grayish, overlaid sparingly with black. Feet white. Belly white, fur gray basally only immediately below lateral line of junction between belly fur and dorsal buffy pelage.

3) *Neotoma f. rubida* (USNM 284878), from ½ mi. N Simpson, Vernon Par., Louisiana, taken November 28, 1948. Dorsal coloration generally dark with mid-dorsal band very well defined, extensive, and prominent. Sides and ground color of mid-dorsal band Ochraceous-Buff, dorsum well overlaid with black-tipped hairs; rump Ochraceous-Buff. Crown and head lighter (Light Ochraceous-Buff) and grayish, overlaid sparingly with black. Feet white. Belly white, fur gray basally on lower sides but not on throat or mid-ventral region.

4) *Neotoma f. illinoensis* (BCS 167755), from Wolf Lake, Union Co., Illinois, taken January 16, 1910. Dorsal coloration generally light with mid-dorsal band moderately well defined. Sides and ground color of dorsum Light Ochraceous-Buff, dorsum extensively overlaid with black-tipped hairs; rump Warm Buff. Crown and head lighter (Light Buff) and grayish, moderately overlaid with black. Feet white. Belly white, fur gray basally only on sides of abdomen.

The degree of saturation of the coloration of the sides distinguishes specimens in fresh pelage of these four subspecies. In general, specimens of *floridana* have

the lightest (yellowish) coloration and are heavily grizzled with black, while *haematoreia* is brighter (more pink) and less grizzled dorsally. *N. f. rubida* resembles *haematoreia* but is still brighter (more reddish) and is moderately grizzled with black, and *illinoensis* is lighter (more tan) than *rubida* but not so light (yellow) as *floridana*. *N.f. illinoensis* resembles *haematoreia* most closely in color, but the former is lighter than the latter, is more grizzled dorsally, and lacks the grayish aspect in the shoulder region. It should be emphasized again that fresh pelage is essential in such comparisons; these color differences are slight at best, and individuals of one race may resemble specimens of another race, due to degree of wear and age of the individual. Comparison of population samples reveals the differences between these forms; comparison of individuals will not. The above descriptions of typical fresh specimens are given to make clear our concept of these subspecies, and in no way express the variation of coloration in each form. These examples were chosen as typical of each race and represent average individuals.

Goldman (*op. cit.*) discussed the cranial differences between the various races of *floridana*. These structural differences are difficult to assess when large series of specimens are examined, and whereas the characters ascribed by Goldman to the various forms may be valid, they do not necessarily characterize these races. The differences noted by him are those of quality rather than quantity, as one expects of subspecies, and so are of little value in deciding whether a particular specimen should be referred to a specific subspecies. The table of cranial measurements (Table 1) serves to show that no significant quantitative differences in skull measurements or proportions exist.

Aside from expanding, delimiting, and defining the ranges of *floridana* and *haematoreia* (which has been known from North Carolina only by an immature specimen from Highlands, Macon County), the major change in nomenclatural assignments has been the designation of the Alabama populations of *floridana* south of the Tennessee River to the race *illinoensis*. Howell (1921: 52-3) assigned the Alabama specimens to the race *floridana* without comment. The same writer (1934: 404) stated that the specimens from south of the Tennessee River in northeastern Alabama are "practically typical *floridana*." Examination by us of twenty-seven specimens from Alabama indicates that these specimens are better assigned to *illinoensis* than to *floridana*. Their coloration is much pinker than is typical of *floridana* throughout its range, and they lack the yellowish general appearance of that race. On the other hand they resemble quite closely in color topotypes of *illinoensis* from Wolf Lake, Union Co., Illinois. Fortunately there is adequate material from Alabama for study. Goldman (*op. cit.*: 23) extended the range of *rubida* into southern Alabama on the basis of a single immature individual from Castleberry, Conecuh County. This is the only individual we have seen from the lower Alabama Coastal Plain (other than from the vicinity of Mobile Bay) and because of its immature pelage, it is impossible to determine whether it really represents *rubida* (as Goldman suggests, probably because he lacked any other lower Coastal Plain specimens

from Alabama except a series of eight from Mobile Bay), *illinoensis* (which it should represent on the basis of geography), or *floridana*. We have examined Goldman's specimens from Mobile Bay, and they most resemble *rubida*, to which race Goldman assigned them. An individual from Marianna, Jackson Co., Florida, is close to *illinoensis*, while another specimen from Tallahassee, Leon Co., Florida, is best assigned to *floridana*. Of a series of five specimens from the vicinity of Apalachicola, Franklin Co., Florida, two most closely resemble *floridana*, and the remainder are *illinoensis*. This has been interpreted by us as indicating that these two subspecies intergrade in this area.

As we understand them, the ranges of the five eastern subspecies of *N. floridana* may be defined as follows (Fig. 1): *floridana*—Peninsular Florida, from Sarasota County on the west coast and Brevard County on the east coast, north in the Coastal Plain to Brunswick County, North Carolina, and west to about the Chattahoochee River and the Georgia-Alabama state line, and the Apalachicola River in western Florida; *haematoreia*—southern Blue Ridge physiographic province, from the Great Smoky Mountains in North Carolina and Tennessee, south to Pickens County, Georgia, and in the mountains of South Carolina; *illinoensis*—southern Illinois and southeastern Missouri, south along the Mississippi River to southeastern Arkansas, bounded on the east by the Tennessee River in Kentucky (?), Tennessee, northern Alabama, and extreme northwestern Georgia, thence south in Alabama, bounded on the east by the Chattahoochee and Apalachicola Rivers; *rubida*—all of Louisiana, west in Mississippi to Mobile Bay, Alabama, and easternmost Texas; *smalli*—Key Largo, Florida.

SUMMARY

A critical study of eastern woodrats of the genus *Neotoma* shows that differences between *N. magister* and *N. floridana* have been exaggerated because most specimens of *magister* available in collections come from the northern part of the range of that form. Most characteristics, both measurements and pelage features, show a north-south cline with differences between populations being of a subspecific nature (Fig. 2). The only justification for considering *magister* as a species distinct from *floridana* and its complex of subspecies rests on certain features of the palatine region of the skull, especially on the shape of the interpterygoid fossa. Since the great weight of evidence indicates that all eastern woodrats are closely related, it seems more fitting to regard *magister* as a subspecies of *floridana*. Accordingly, we would recognize six eastern subspecies of *Neotoma floridana*, as follows:

Neotoma floridana floridana (Ord), 1818
Neotoma floridana magister Baird, 1858
Neotoma floridana rubida Bangs, 1898
Neotoma floridana illinoensis Howell, 1910
Neotoma floridana haematoreia Howell, 1934
Neotoma floridana smalli Sherman, 1955

The distribution of all six races is brought up to date (Fig. 1) and, on the basis of coloration, Alabama specimens are assigned to *illinoensis* instead of to *floridana*.

APPENDIX

Listed below are all the specimens that were examined in the course of this study:

Neotoma f. floridana: *North Carolina*, Brunswick Co., Smith Island, 11. *South Carolina*, Georgetown Co., Cat Island, 3; Kinloch Plantation, 12 mi. S Georgetown, 7; Belle Isle Plantation, 1; Berkeley Co., Otranto, 13; Charleston Co., McClellanville, 1; 6 mi. N McClellanville, 2; 9 mi. NE Mt. Pleasant, 1; 7.5 mi. W Charleston, 1; John's Island, "Orange Hill," 1; Seabrook's Beach, 14; Beaufort Co., Frogmore, 1; Aiken Co., Savannah River Project, 4; 1 mi. SW Ellenton, 1. *Georgia*, Screven Co., Hursman's Lake, 2; McIntosh Co., Valona, 3; Liberty Co., Riceboro, 6; Camden Co., Crooked River State Park, 4; Spanish Mission, 4.3 mi. S Crooked River State Park, 1; Dougherty Co., Reynold's Refuge, 7; Washington Co., Baldwin's Bluff, nr. Milledgeville, 1; Bibb Co., south of Macon, 2; Houston Co., Perry, 1; Grady Co., Cairo, 1. *Florida*, Duval Co., New Berlin, 15; Leon Co., Tallahassee, 1; Franklin Co., Apalachicola, 1; 2 mi. W Apalachicola, 2; 10 mi. above mouth Apalachicola River, 2.

Neotoma f. illinoensis: *Illinois*, Union Co., Wolf Lake, 7; 6 mi. N Wolf Lake, 1; Pine Hills, 2. *Missouri*, Reynolds Co., Black, 2. *Arkansas*, Crittenden Co., Big Creek, 4; Desha Co., McGehee, 1. *Tennessee*, Obion Co., Reelfoot Lake, 3.5 mi. SE Samsburg, 1; Marion Co., Nickajack Cave, 2. *Alabama*, Colbert Co., Leighton, 3; 10 mi. N Leighton (not mapped), 1; Jackson Co., Sand Mountain, 1; DeKalb Co., Mentone, 1; Calhoun Co., Choccolocco Mountains, nr. Bain Gap, 2; Clay Co., Dean, 2; Tuscaloosa Co., 4 mi. N Tidewater, Lock 14, 3; Autauga Co., Autaugaville, 6; 4 mi. NE Autaugaville, 1; Montgomery Co., Barachias, 6; Conecuh Co., Castleberry, 1. *Georgia*, Dade Co., Case Caverns, 1; nr. Trenton, 1. *Florida*, Jackson Co., Marianna, 1.

Neotoma f. rubida: *Louisiana*, Vernon Par., 0.5 mi. N Simpson, 1; St. Landry Par., 0.5 mi. S Palmetto, 1; St. Mary Par., Morgan City, 4; Franklin, 2; Terrebonne Par., Houma, 2. *Mississippi*, Hancock Co., no other locality, 8; Bay St. Louis, 11. *Alabama*, Mobile Co., Mobile, 5; Mobile Bay, 1; Mobile River, 1.

Neotoma f. haematoreia: *North Carolina*, Haywood Co., Crestmont C.C.C. Camp, 1715 ft., 1; Big Creek Ranger Station, 1600 ft., 1; Macon Co., Highlands, 4000 ft., 1. *Tennessee*, Blount Co., Tremont C.C.C. Camp, 1925 ft., 3; Tremont Junction, Tenn. 73, 1147 ft., 2; bet. Sinks and Great Smoky Mountains National Park line on Little River, 1200 ft., 1; Sevier Co., The Sinks Bridge, 1565 ft., 3. *South Carolina*, Greenville Co., 0.9 mi. S Caesar's Head Lodge, 2; Pickens Co., summit of Sassafras Mountain, 1; Oconee Co., 1.5 mi. NW Jocassee, 1000 ft., 2. *Georgia*, Lumpkin Co., summit of Blood Mountain, 4440 ft., 1; Frogtown Gap [Neel's Gap], 3100 ft., 4; 5 mi. NE Suches, Blood Mountain, 1; 1 mi. N Camp Wahsega, 1800 ft., 1; Union Co., Hawk Mountain summit, 1; top of Blood Mountain 1; bet. Towns and Union Cos., nr. summit Brasstown Bald, 1; Pickens Co., Burnt Mountain, 3400 ft., 3.

Neotoma f. smalli: *Florida*, Monroe Co., Key Largo, 24.

Neotoma f. magister: *New York*, Orange Co., West Point, 11. *New Jersey*, Passaic Co., 1.5 mi. W of south end Greenwood Lake, 2. *Pennsylvania*, Lycoming Co., Rattling Camp Run, 6.5 mi. S Nisbet, 1; Centre Co., Cherry Run, 2.9 mi. S Woodward, 1; Cherry Run, 2.3 mi. SE Woodward, 2; Union Co., Penn Creek Mountain, 1 mi. S Gleniron, 2; Schuylkill Co., 4 mi. SE Pine Grove, 1440 ft., 1; Berks Co., The Pinnacle, 3 mi. NNW Lenhartsville, 3; 2.25 mi. NW Lenhartsville, 1; 4 mi. SW Echville, 1600 ft., 1; Cumberland Co., 6 mi. from Pine Grove, South Mountain, 1; South Mountains, nr. Pine Grove Furnace, 1; Lancaster Co., 0.25 mi. S Safe Harbor, 250 ft., 1; Lehigh Co., Bake Oven Knob, 1500 ft., 1; Bedford Co., Cooks Mills, top of Savage Mountain, 2; 2 mi. E Osterburg, 2100 ft. 2; Fulton Co., 4.5 mi. S Crystal Spring, 1740 ft., 1; Mifflin Co., 3 mi. WSW Milroy, 1100 ft., 1; Franklin Co., 5.25 mi. ESE Mont Alto, 1950 ft., 1; Clinton Co., Round Island, 3; 3 mi. N Round Island, 1; 4 mi. NE Round Island, 2.

West Virginia, Pendleton Co., 2.1 mi. N Upper Tract, 1500 ft., 2; 1 mi. S Smoke Hole P.O., 1; Randolph Co., 3.8 mi. W Elkwater, 3350 ft., 2; 8 mi. E Pickens, 3400 ft., 1; Pocahontas Co., 2 mi. NW Front, 3500 ft., 1; 0.5 mi. N Huntersville, 2250 ft., 1; Fayette Co., Babcock State Park, 2000 ft., 2; Grant Co., 4 mi. W Petersburg, 1; Wayne Co., 2.5 mi. S Lavalette, 600 ft., 1; Nicholas Co., 3 mi. SW Sparks, 1700 ft., 1; Kanawha Co., Kanawha State Forest, mouth of Shrewbury, 750 ft., 3. *Ohio*, Hocking Co., Rockbridge, 1; Sec. 15, Goodhope Twp., 2. *Virginia*, Giles Co., Mountain Lake, 1; 1 mi. E Mt. Lake, 1; summit of Butt Mt., 4100 ft., 1; Castle Rock [Wind Rock], Big Mt., north of Mt. Lake, 4100 ft., 2; Russell Co., Daugherty's Cave, 1; Roanoke Co., Dixie Caverns, 1. *Indiana*, Harrison Co., no other locality, 1; Tobacco Landing, 3. *Kentucky*, Carter Co., Carter Caves, 2; Boyd Co., Catlettsburg, 1; Edmondson Co., Mammoth Cave, 1; Breathitt Co., Lost Creek, 1; Hancock Co., Hawesville, 1. *Tennessee*, Montgomery Co., Clarksville, 1; Lawrence Co., Lawrenceburg, 1; Humphreys Co., Buck River, 6 mi. SW Waverly, 2; Hamilton Co., Walden Ridge, nr. Soddy, 7. *Alabama*, Lauderdale Co., Muscle Shoals, 10 mi. SE Florence, 3; Marshall Co., Gunters Mt., Ft. Deposit, 1; Madison Co., Huntsville, Monte Sano, 1600 ft., 2; Jackson Co., Woodville, 2 (not mapped). *North Carolina*, Avery Co., Grandfather Mt., 4100 ft., 3.

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Dept. of Biology, Albright College, Reading, Penna., and Dept. of Zoology, University of Georgia, Athens, Georgia. *Received March 8, 1956.*

REPRODUCTION IN *PEROGNATHUS*

By Kenneth L. Duke

It is interesting, yet astounding, that so little definite information is available concerning various phases of reproductive activity in the great majority of mammalian species. Often assumptions have been made on the reproductive activity of a certain genus or species based on information obtained from studying laboratory mammals or taxonomically related individuals. Such assumptions are often useful. But the user must always accept them only as assumptions, being willing to forsake them at the proper time, realizing that they are permitted by our ignorance and not always sustained by our knowledge.

Very little has been published, to my knowledge, on the reproductive cycle of the genus *Perognathus*. The results of this study are presented to assist in rectifying this condition.

MATERIALS

All the specimens used in this study were collected in the state of Utah; most of them from various stations on the west desert, but some from the highlands of the central and eastern portions of the state. Three species of the genus are represented: *Perognathus formosus, P. longimembris,* and *P. parvus*. Although a year-round collection of material would be highly desirable, it was not realized in this study. The dated collections are as follows: April—4 females, 18 males; May—no females, 3 males; June—20 females, 25 males; July—18 females, 7 males; August—10 females, 13 males; September—1 female, 4 males; October—no specimens; November—2 females, no males; December—no females, 1 male. Reproductive tracts of 26 females and 25 males were sectioned and used in this study.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge two sources of aid without which this study would not have been possible: Dr. C. Lynn Hayward, Department of Zoology, Brigham Young University, who supervised the collection of most of the specimens; and a grant from the Duke University Research Council.

DESCRIPTION AND DISCUSSION

A histological study of the reproductive tracts of *Perognathus* reveals evidence indicating that the genus has a restricted breeding season in Utah. Because of the paucity of specimens taken during the period from January to June, it is not possible to determine exactly how early in the year reproductive activity is initiated. Some observations, however, suggest this activity begins at least as early as the first part of April. The earliest pregnancies recorded, in this collection, were in two females obtained April 18, 1952, in southern Utah (Beaver Dam Wash area in Washington County). Even the least advanced of the two pregnancies (Plate I, *A*) is at a stage warranting the conclusion that these pregnant females must have mated in early April. This conclusion is based on the

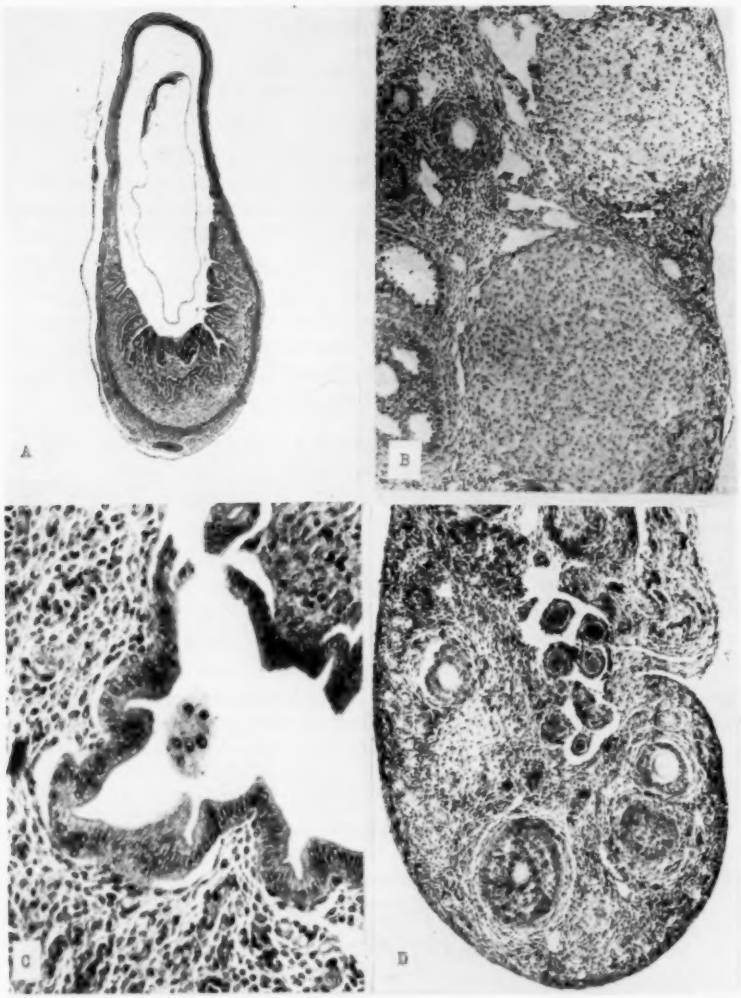

PLATE I

A: Section of the uterus of a pregnant female collected April 18, 1952. The embryo is in the neural fold stage of development; amniogenesis is well under way. In some other rodents this stage of embryonic development is attained in about 7 days. 19×. *B*: Section of the ovary of a pregnant female captured July 19, 1951. Two sets of corpora lutea are visible. The body at the upper right is a regressing corpus luteum of an earlier cycle. The larger body at the lower right is the corpus luteum of the current pregnancy. 96×. *C*: Section of the uterus of a female in early pregnancy, showing the unimplanted embryo. The ovary of this female is shown in *B*. 241×. *D*: Section of the ovary of a female captured in August, 1950. The patch of light-colored cells (left center) represents the remains of a corpus luteum. These bodies evidently regress and disappear fairly rapidly. 96×.

assumption that the genus has a somewhat typical rodent-like gestation period of 20 to 30 days duration. This assumption must be made, since to my knowledge the gestation period of *Perognathus* has not been determined. The testes of males collected at this time show full spermatogenic activity (Plate II, *A*).

The greatest number of pregnant females was recorded during the month of June, when 12 of 20 females collected were found to be pregnant. The only other pregnancies occurred in two females collected in April and one in July. No histological evidence for reproductive activity was observed in the reproductive tracts of females collected after early July.

Two of the females collected in June (both *P. parvus*) were found to have two sets of corpora lutea in their ovaries (Plate I, *B*). The uterus of one of these females contained unimplanted embryos in the morula stage of development (Plate I, *C*). This is the only evidence suggesting the possibility of more than one litter being borne during the course of a year. No other females had more than one set of corpora lutea. These luteal bodies do not persist as discrete bodies for any great length of time; of the females collected later than June, only two showed luteal remnants in the ovaries (Plate I, *D*).

Concerning the litter size: the mode was 5, the average 5.38.

During the reproductive season, the testes show large seminiferous tubules

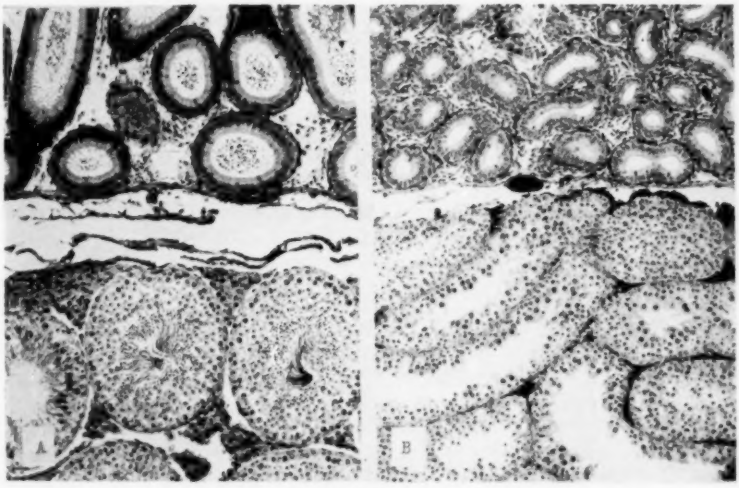

PLATE II

A: Section of testis and epididymis of a male captured in June, 1951. Seminiferous tubules are large and active; note the size and numbers of interstitial cells. The tubules of the epididymis are large, lined with high columnar epithelium, and contain many spermatozoa. 89×. *B*: Section of the testis and epididymis of a male captured in August, 1950. Compare this with *A* and note the reduction in size of the seminiferous tubules, the retarded germinal activity, and the inconspicuousness of the interstitial cells. There is also a reduction in the diameter of the tubules of the epididymis and in the height of the lining cells; spermatozoa are absent. 89×.

(280μ in diameter) in full spermatogenic activity (Plate II, *A*). The interstitial cells of Leydig are very numerous and occur in large aggregations between adjacent seminiferous tubules (Plate II, *A*). The epididymides of these males exhibit dilated tubules (160μ in diameter) and contain numerous spermatozoa (Plate II, *A*). Atrophy of the testis and epididymis begins in July, and by August the seminiferous tubules exhibit practically a 50 per cent reduction in diameter (140μ; Plate II, *B*). Spermatogenic activity is greatly reduced, and the interstitial cells become quite inconspicuous. The tubules of the epididymis become reduced in size (60μ in diameter) and contain no spermatozoa (Plate II, *B*).

With reference to the reproductive pattern in *Perognathus*, Anthony (Field Book Of North American Mammals, 1928: 311–312) states: "The number of young varies from four to seven but is usually four or five. Several litters may be raised in a year over most of the range of the genus, although the northern forms probably rear but one family a season." Hall's records (Mammals Of Nevada, 1946: 366, 371) on the genus in Nevada suggest that *P. longimembris* has but one litter per year with most of the pregnancies occurring in the month of May. For *P. parvus* he states: "young born in May, June and July;" and for *P. formosus*, of 91 adult females taken "only two contained embryos. These were animals taken in July."

SUMMARY

In Utah both the male and female of the genus *Perognathus* have a restricted period of reproductive activity during the year: from early April (perhaps earlier) to early July. Two litters may be borne by some females, especially in the southern limits of the range, and in the early breeders, but one is probably more common. The average litter size is 5.38 and the mode is 5.

Department of Anatomy, Duke University School of Medicine, Durham, North Carolina. *Received April 14, 1956.*

POSSIBLE NATURAL INTERGRADATION BETWEEN PRAIRIE AND FOREST DEER MICE

By Kile R. Barbehenn and John G. New

The eastward extension of the range of the prairie deermouse, *Peromyscus maniculatus bairdii*, has been noted by several authors: Osgood (1909: 80), Moulthrop (1938: 503), Hooper (1942: 193), Wilson (1945: 95), Hamilton (1950: 100), and Stickel (1951: 25). Hooper (*op. cit.*) hypothesized that *P. m. bairdii* would come into contact with other races of this species as it extended its range to the east due to the clearing of the land by lumbering and cultivation. *Peromyscus m. bairdii* and the forest deer mouse, *P. m. gracilis*, are in contact in western and central New York but ecologically isolated. The former inhabits grasslands, open fields and lake beaches while avoiding woodlands. The latter dwells in forests and avoids open fields and grasslands. Direct intergrada-

tion between these two subspecies in nature has not been recorded in the literature (Dice, 1931: 210; Hooper, 1942: 195; Blair, 1950: 263). Dice (*op. cit.*) and others have demonstrated intergradation in the laboratory and the young proved fertile. There has been no evidence that *gracilis* and *bairdii* live together in the same habitat.

This paper describes an instance where both forms were found living together in old field habitats in the Arnot Forest, Tompkins County, New York, during the summer and fall of 1954, and presents the results of an analysis for possible intergrades.

History and biological characteristics of the Arnot mice.—During the summer of 1952, a total of 200 stakes set 50 feet apart were placed in lines through old fields on the Arnot Forest. Three snap traps were set at each stake for three nights each during that summer and the early spring and late summer of 1953 and 1954. The white-footed mouse, *Peromyscus leucopus*, was taken frequently, usually in association with hedgerows or brushy spots, but also in the open fields. One *bairdii* was trapped in the spring of 1953 and five in the fall of that year. *Peromyscus m. gracilis* was known to inhabit the adjacent woods on the Arnot (and also on Connecticut Hill, where three other fields were being censused) but was not taken in the fields. In September, 1954, the Arnot fields fairly swarmed with deer mice. The three forms together nearly equalled a peak *Microtus* population in one field. A total of 33 *gracilis*, 11 *bairdii* and 20 *P. leucopus* was taken in three nights.

The habitats used by *gracilis* were identical to those occupied by *bairdii*—sparse timothy-weed associations, pure poverty grass (*Danthonia*), and areas of lichens, hawkweed (*Hieracium*) and pussy-toes (*Antennaria*)—all low in cover. There is little doubt that these forest deer mice were living in the fields—not merely passing through. Several were taken at burrow entrances, and a typical rapid drop-off in the 3-day catch occurred. From the first to the third day, the numbers of *gracilis* taken were 23, 9, and 1. The combined numbers of *bairdii* and *P. leucopus* were 21, 8, and 1. One would not expect such a response from active immigrants.

On November 18, 1954, favorable parts of the fields and adjacent woods and hedgerows were trapped for one night with about 120 traps. Six *P. leucopus*, one *gracilis* and one *bairdii* were taken. The single *gracilis* was taken beneath an apple tree in an open field. The population of *gracilis* had apparently decreased greatly.

TABLE 1.—*Breeding condition of Arnot mice in adult pelage, Sept. 9–11, 1954*

SEX	*P. m. gracilis*		*P. m. bairdii*		*P. leucopus*	
	BREEDING	NON-BR.	BREEDING	NON-BR.	BREEDING	NON-BR.
Males	0	12	6	0	1	5
Females	7	12	3	1	6	3
Total	7	24	9	1	7	8

TABLE 2.—*"Age" distribution of Arnot mice (after Cockrum, 1954: 367)*

AGE	*P. m. gracilis*		*P. m. bairdii*		*P. leucopus*	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
2 (juv. pel.)	0	0	0	1	3	2
3	6	10	3	3	2	3
4	4	4	3	1	3	3
5	1	3	0	0	0	2
6	1	2	0	0	1	1
Total	12	19	6	5	9	11

The structure of the populations of *gracilis* and *P. leucopus* on the Arnot may be somewhat unusual, with females making up about two-thirds of the catch (Table 1). Of the *gracilis*, seven had placental scars and corpora lutea, and two of these mice were lactating. All males of *gracilis* were judged to be non-fertile, although tooth-wear (Table 2) indicated that several of these were "old" animals. The testes of several had apparently regressed. No juvenile *gracilis* were taken. One each of the *bairdii* and *P. leucopus* females was pregnant, and all of the *bairdii* males were fertile (based on accessory glands as well as testes) despite the large number of young animals.

On the basis of this limited data, it is not possible to say with much assurance that fertile *gracilis* were actually in contact with fertile *bairdii*, but the likelihood existed.

Materials.—To compare the characteristics of other populations with these Arnot mice, the following collections were used: 16 additional *P. leucopus* from the Ithaca region, various dates, Barbehenn and New; 5 *P. leucopus* from the Blue Ridge Mountains, Green Co., Virginia, November 12, 1955, Barbehenn and Robert B. Chapoton; 18 *P. m. gracilis* from the Catskill Mountains, New York, various dates, New and W. J. Hamilton, Jr.; 10 *P. m. nubiterrae* from the Blue Ridge Mountains, Green Co., Virginia, November 12, 1955, Barbehenn and Chapoton; and 29 *P. m. bairdii* from other areas around Ithaca, including some of those taken from the Arnot on earlier dates. Dr. Rollin H. Baker (then of the University of Kansas) loaned us skeletal material of 11 *P. m. bairdii* from Kansas and we acknowledge with thanks his assistance. Dr. W. Robert Eadie of Cornell University kindly supplied us with seven specimens of *P. m. maniculatus* collected near Lake Nipigon, Ontario, Canada, in August, 1955. Dr. W. J. Hamilton, Jr., helped us identify some of our material. The subspecific names used in this paper follow Miller and Kellogg (1955).

Methods.—The mice were identified in the flesh at the time of capture. *Peromyscus leucopus* was separated from *P. maniculatus* on the basis of pelage; thickness and hairiness of bicolored tail; and facial characters. Total length, tail length and hind foot measurements were made to the nearest millimeter in the usual fashion, and ear lengths were measured from the notch. Weights, pelage and reproductive condition were recorded when possible. A few skins

were prepared, but most of the material was skeletonized by dermestids. The Ontario mice were preserved in the field and cleared and stained with Alizarin red S in the laboratory.

The following features of the skull were noted: (1) the distance from the posterior border of the palatine foramina to a line drawn across the front of the first cheek teeth; (2) the shape of the palatine foramina; (3) the exposure of the infraorbital foramen when viewed from the side; and (4) the age of the animal as determined by amount of tooth-wear (Cockrum, 1954: 367).

Of the several skeletal measurements taken, those referred to in this report are: (1) greatest length of femur (measured from the condyles to the dorsal surface of the head); (2) length of the three longest caudal vertebrae (measured using dividers and a millimeter rule at several places along the air-dry, intact, skeletonized tail, until the three longest adjacent vertebrae were determined to the nearest 0.5 mm.); and (3) the number of caudal vertebrae (determined by counting from the first caudal lacking prominent transverse processes to the last tiny bone, inclusive). Clearing and staining indicated that what appears to be a cartilaginous tip following the last conspicuous vertebra normally contains one or two tiny bones. Their position can be noted in dried tails, and they are included in the count.

The obvious major problem at hand is how to identify intergrades. There is no information on this subject in the literature. McIntosh (personal letter, 1955) states only that they would be "intermediate." McIntosh's (1955) paper is the most recent work concerning a statistical approach to the comparison of the two *P. maniculatus* populations. One readily concludes from his Figure 7 that the regression of skull width, skull depth, skull length, and humerus length on femur length are of little use for this problem. An intermediate individual might be part of the normal distribution of either population. His regressions of tail length, hind foot length, and ear length on body length (Figure 8) look more promising, but he has not established confidence intervals about his means. A general criticism of external measurements is that there is variation in methods of measuring among collectors, tail tips may be missing and ears chewed off by insects. Errors made originally cannot be corrected. Of the several morphological features of the skull examined here, none served completely to separate the two populations. A logical place to look for measurable differences is in the tail.

Results of morphological analyses.—Figure 1 summarizes the comparisons of several populations of *gracilis, bairdii,* and *P. leucopus* based on the number of caudal vertebrae, lengths of vertebrae, and the sums of the two figures for individuals.

It is obvious from the vertebral counts that *bairdii* is readily separated as a population from *gracilis* and *P. leucopus.* Although none of the individual counts of these two populations of *P. maniculatus* overlapped, it is possible that larger samples will increase the range of one or the other form. *Peromyscus leucopus* is nearly identical in count to *gracilis,* and a few (3 of 28) individuals

have counts as low as those of *bairdii*. Within the forest forms there seems to be a north–south cline in vertebral counts, with *P. m. nubiterrae* significantly higher than the others. Since the ranges of the counts overlap completely, this may be simply an artifact of a small sample.

Vertebral length criteria indicate highly significant differences between the prairie and the forest populations of *P. maniculatus*, with *P. leucopus* intermedi-

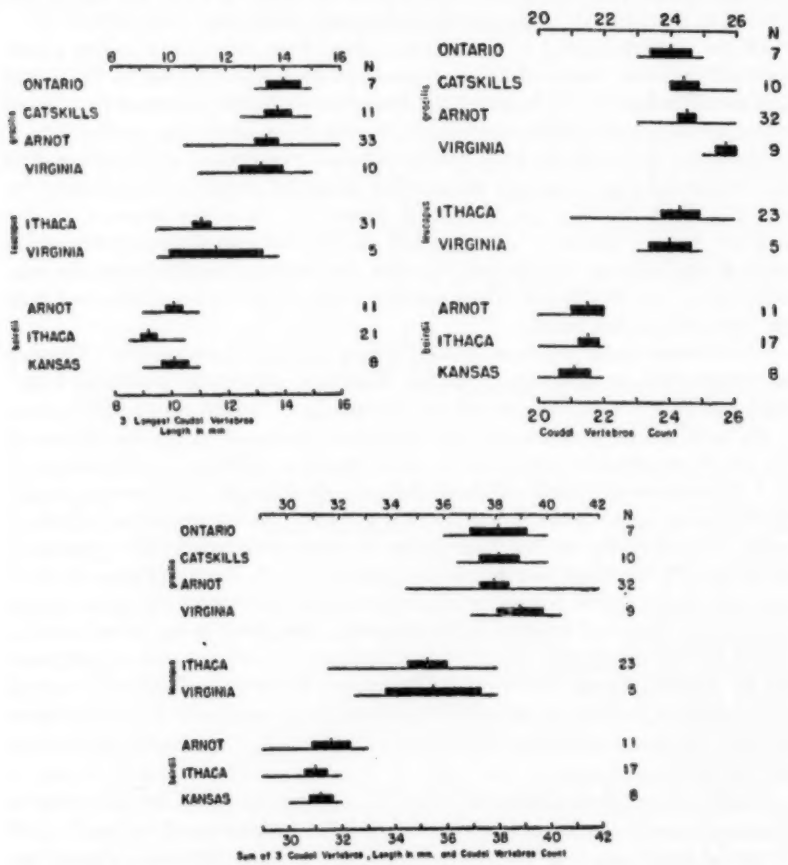

FIG. 1.—TOP LEFT: Comparisons of 3 longest caudal vertebrae (length in mm.) for several populations of adult deer mice. TOP RIGHT: Comparisons of caudal vertebral count for several populations of adult deer mice. BOTTOM: Comparisons of the sum of length of the 3 longest caudal vertebrae (length in mm.) plus the number of caudal vertebrae for several populations of adult deer mice. The horizontal line indicates the range of the sample, the vertical line the mean of the sample, and the black box indicates two standard errors of the mean on either side of the mean. *N* indicates the sample size.

ate. Two of the *gracilis* from Arnot and one of the *nubiterrae* from Virginia overlap the range of *bairdii*. The significant difference between *bairdii* from the Arnot and those from the Ithaca area (Fig. 1) is due to a heavy bias of small mice in the Ithaca sample, and serves as a warning against using this measurement in comparing samples that differ in absolute size. Nevertheless, absolute size is a major difference between *bairdii* and both *gracilis* and *P. leucopus* and can be used to good advantage where age structures are similar. The high variation in *P. leucopus* from Virginia is not readily explained.

Combining the lengths and numbers of vertebrae (Fig. 1) provides a complete separation of the forest and prairie groups, and gives a statistically significant separation of *P. leucopus* from both kinds of *P. maniculatus*. The validity of such a procedure may be open to some question because of the positive relationship of the vertebral lengths to absolute size (Fig. 2), but it serves, at least, to focus attention on extreme individuals. Three *gracilis* from the Arnot fall below the ranges of any of the other forest forms, and one above. This greater range is probably a function of sample size, since the coefficients of

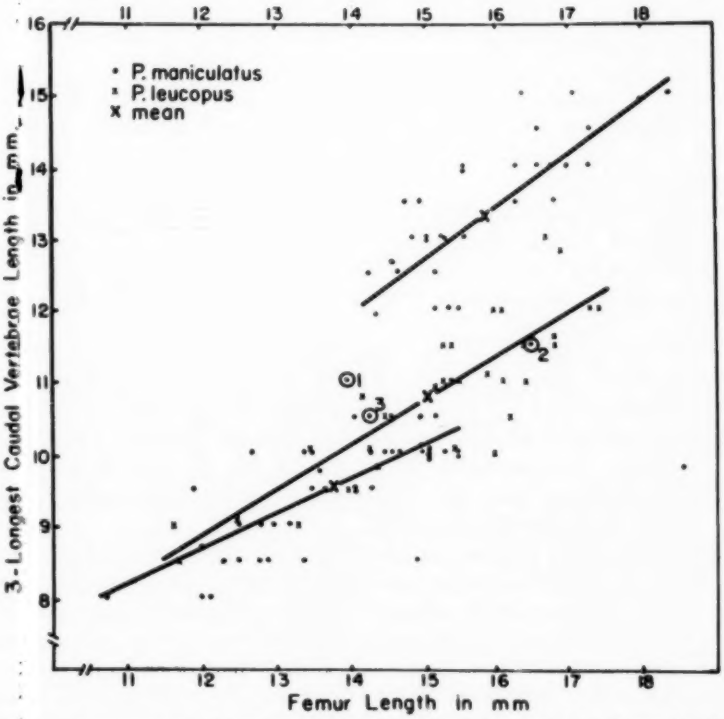

FIG. 2.—Regressions of 3 longest caudal vertebrae (length in mm.) on femur length for *P. m. gracilis* (upper line), *P. leucopus* (middle line) and *P. m. bairdii* (lower line).

variation for all samples are of the same general magnitude, with the exceptions of vertebrae length of *P. leucopus* from Virginia and vertebrae number of *P. leucopus* from the Ithaca area.

Plotting the regression of vertebral length on femur length for *gracilis* from the Arnot, *bairdii* from the Arnot and Ithaca, and *P. leucopus* from the Ithaca area (Fig. 2) indicates that the vertebrae of *gracilis* are longer than those of the *bairdii* because of absolute size, because of a highly significant difference in adjusted means of the regression, and because of a somewhat steeper slope for *gracilis*. A test for the significance of difference in slope (0.74 for *gracilis* and 0.45 for *bairdii*) gives a probability value between 0.10 and 0.05. A somewhat larger sample should establish the statistical significance of this difference. The mean difference in vertebra lengths between the two subspecies of *P. maniculatus* is greater than the mean difference in skull lengths. At a femur length of 15 mm., 3-vertebrae lengths of *bairdii* average 10.1 mm. and of *gracilis* 12.6 mm. ($d = 2.5$ mm.). At the same femur length, the skull lengths average approximately 23.5 mm. for *bairdii* and 24.5 mm. for *gracilis* ($d = 1.0$ mm., from McIntosh, Fig. 7). The difference between *P. leucopus* and *bairdii* is due chiefly to size, while the difference between *P. leucopus* and *gracilis* is due chiefly to adjusted means of regression.

Figure 2 draws attention to three mice, as indicated by the circled points. Number 1 is a breeding, female *bairdii* from the Arnot. Original measurements are: TL 160, T 65, HF 17, Ear 16. These figures and the vertebral count of 22 are all typical of *bairdii*, so there is little reason to suspect this mouse of being an intergrade.

Number 2 is an adult male *gracilis*. Original measurements are: TL 168, T 80, HF 22, Ear 19. The vertebral count is 25. The tail and ear measurements are somewhat low, but not abnormally so. This animal may be an unusual extreme in its 3-vertebrae measurement, or it may be a backcross of an intergrade to *gracilis*.

Of the mice handled, only No. 3 raises very serious doubts as to its monogenetic ancestry. This mouse was originally identified as *gracilis* with the following measurements: TL 155, T 74, HF 20, Ear 16. The vertebral count is 24 and the three longest tail vertebrae measure 10.5 mm. The femur is 14.3 mm. long. The skull was examined by Dr. W. J. Hamilton, Jr., who called it *bairdii*. If the animal is not an unusual *P. leucopus*, it qualifies well for being a natural intergrade between *bairdii* and *gracilis*.

Discussion.—There is no way of estimating the frequency with which *gracilis* and *bairdii* come into association with each other, or to predict the outcome of such events. It appears that ecological barriers break down under the stress of high population density. If this occurs without loss of fertility, natural interbreeding may occur between the two subspecies. It may be pointed out that the population of *gracilis* on the Arnot did appear to be low in fertility, but the breeding condition of these September-caught mice is not necessarily a valid indication of their condition when they immigrated to the fields. One might

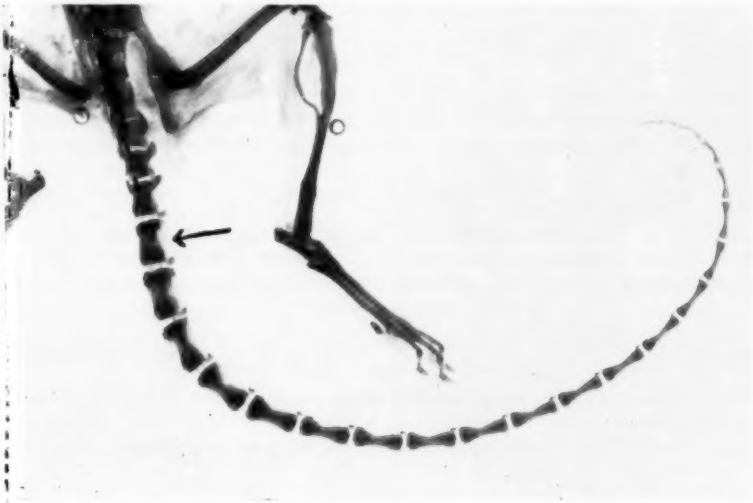

PLATE I

Tail vertebrae of *Peromyscus m. maniculatus*. Arrow points to the first vertebra included in the count. The count is 23 for this specimen. The last tiny vertebra does not show; only 22 are visible in this photograph.

also raise the objection that the *gracilis* would be more likely to mate with each other than with *bairdii*. This may be true, but the high mortality following a break by isolating individuals would decrease the probability of an individual *gracilis* being able to find a suitable mate.

Identification of intergrades is a critical problem. The meristic character afforded by the caudal vertebrae appears to be extremely useful, but requires careful standardization—just as with scale and fin-ray counts of fish. We suggest beginning with the first caudal vertebra outside of the body proper because it can be counted accurately without cleaning the tail, and is readily identified after cleaning. Inclusion of the last poorly formed vertebra precludes any temptation to make counts on tails lacking the very tip. The lengths of the caudal vertebrae appear to give better separation of the two forms than does skull length—the best skeletal measurement thus far investigated. It is suggested that a more valid comparison of vertebral lengths could be obtained if all were adjusted to a fixed femur length (*i.e.*, 15.0 mm.) by regression analysis.

One might predict that the ultimate result of occasional mixing of the two populations would be a gradual shifting of the morphological characters of the populations toward each other. If such an event is to be recorded and measured adequately, it is essential that large series (25 to 50) of complete skeletons be preserved from localities where the populations are now known to be geographically isolated, but where they are likely to make contact.

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Comparative Physiology Branch, Army Chemical Center, Maryland; and Science Department, State University Teachers College, Oneonta, New York. *Received May 11, 1956.*

INFLUENCE OF DAYLENGTH ON ACTIVITY OF THE VARYING LEMMING

BY RICHARD M. HANSEN

The importance of lemmings in the arctic and subarctic regions has long been recognized, but there is little known about their ecology. The cause of cyclic populations in these animals remains unknown. In all of the studies so far recorded, the die-off has been in the winter or early spring following a population peak. At this time (in late winter) the length of daylight begins to increase, and it has been postulated that the increased light stimulates most mammals into sexual activity (Christian, 1950). This has not been demonstrated in the varying lemming, and furthermore, these animals are reproductively active at all periods of the year (Degerbøl and Møhl-Hansen, 1943; Manning, 1954; Ross, 1835; Sutton and Hamilton, 1932).

Elton (1942) indicated that intraspecific factors may be the primary causes of population fluctuations. Errington (1946) included "fighting" as one of the intraspecific mechanisms which he believed basically determined population levels. Chitty (1952) puts forth the hypothesis that fighting produces physiological changes in parents which give rise to abnormalities in the young.

Clark (1953) showed the effects of fighting on the adrenals, thymus and spleen of the vole *Microtus agrestis*, and stated that it produced a "weakened" condition in voles. Since fighting is a part (or result) of activity, it was deemed desirable to study the activity of varying lemmings, *Dicrostonyx groenlandicus rubricatus* (Richardson), in relation to increased daylengths. Moreover, most intraspecific interactions are the result of activity and/or activity patterns.

Methods and materials.—A litter of varying lemmings was collected at Umiat, Alaska, and transported to Fort Collins, Colorado. They survived to breed and establish a laboratory colony, on which this study is based.

Four animals (2 males, 2 females) were housed in separate cages. Each cage was approximately 23.5 cm. wide by 28.5 cm. long and 28.5 cm. in total height. Each was provided with 4 cm. of dry litter and a nesting box. A wire was suspended within each cage in such a manner that when it was deflected in any direction, it would close a contact in an electrical circut, thereby activating a 1½-volt motor which operated a recording pen on a revolving drum. Four simultaneous recordings of the activity of 4 different animals were recorded on a tape which was passing over a drum at a constant rate of 36 cm. each 24-hour period.

Activity records consisted of 4 series of vertical pen strokes indicating the deflection of the suspended wire at any given period. A transparent ruler marked in 15-minute intervals was placed over each record, and the activity noted as plus or minus for each quarter-hour interval of the activity record. Observations and activity recordings taken prior to and following the experiments showed that varying lemmings have periods of activity followed by distinct periods of rest. When the animals are active, they run about the cages, scratching, digging, and occasionally eating. The intervening periods of rest are spent in the nest box where the animals are usually found to be asleep. The recordings on the tape for periods of activity were often so close together that it was impossible to count each pen stroke. Therefore, quarter-hour intervals recorded as plus or minus seemed the most practical means by which any single, sustained period of activity could be measured, and yet minimize the possibility of including two such groupings and an intervening period of rest.

The amount of light to which varying lemmings are exposed under natural conditions is modified by their own habits. They live in surface runways, that are often unexposed, and in underground tunnels and nests that are covered by a blanket of snow for the greater part of the year. During the periods of illumination in the laboratory, however, the length of time an animal was exposed to light was determined by the length of time it remained out of the nesting box. In this respect, the effects of light on activity in the laboratory may be similar to those found in nature.

Recordings prior to and following the experiments showed that lemmings adjust their activity to different daylengths rather quickly. In each series of control, activity became adjusted to changed daylengths within a two-day period. Therefore, the animals were allowed ten days to adjust prior to record-

ing their activity for each experiment. To approximate light conditions in the Arctic during the periods of lowest light intensities (December-January), the cages were maintained in total darkness. The next activity records were taken at normal daylengths. At the time of these recordings there were approximately nine and one-half hours of daylight. To approximate continuous daylight, as experienced by lemmings in the Arctic during the summer, the cages were illuminated continuously with artificial light and the activity of the lemmings recorded. The animals were subjected to total darkness immediately following the recordings for continuous light. The activity records for the third day following the change did not differ significantly from previous records taken in total darkness.

Recordings were conducted on two males and two females of the same litter. They were 35 days old when the first ten-day adjustment period began, 45 days old at the time for the first recording period, and 80 days old at the conclusion. The electrical terminals were stationary for the duration of the three different experiments. A continuous recording of temperature was made during each series of recordings. The temperature was maintained at an average of 50° F. with only minor variations. Each recording period lasted for five consecutive days, started at midnight.

Results of experiments.—The accumulated data are summarized in the following tabulation:

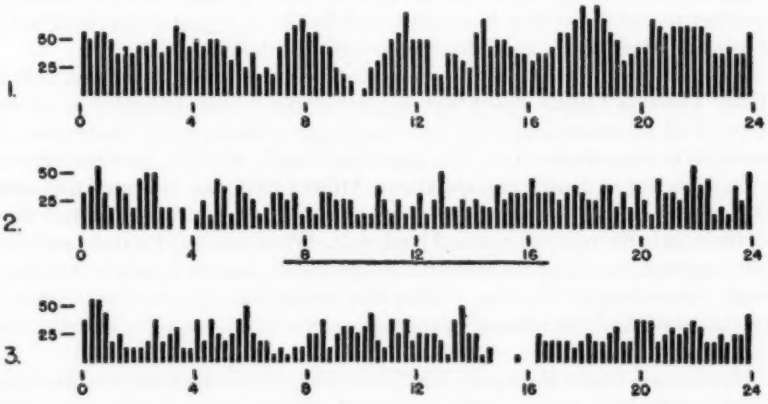
	No. 1♂	No. 2♀	No. 3♀	No. 4♂	TOTALS
Total darkness:					
Number of active periods for 5 days	58	29	35	50	170
Number of quarter-hour periods of recorded activity in 5 days	176	41	292	196	601
9.5 hours of normal daylight:					
Number of active periods for 5 days	44	22	50	57	173
Number of quarter-hour periods of recorded activity in 5 days	79	32	204	111	426
Continuous light:					
Number of active periods for 5 days	45	67	25	45	182
Number of quarter-hour periods of recorded activity in 5 days	60	109	87	108	364

Discussion.—Figures 1 to 4 show the amounts of activity in relation to daylengths, and frequency of activity. There is a reduced amount of activity as the length of the photo period is increased. In total darkness animals were active 31.3 per cent of the time; for 9.5 hours of light, activity was reduced to 22.2 per cent; and in continuous light, the amount of activity was 18.9 per cent. However, the average number of activity periods for each day remained rather con-

stant. There was an average of 8.50 active periods each day during total darkness; 8.65 active periods for 9.5 hours of daylight; and an average of 9.10 active periods per day for continuous light. The average length of the activity period decreased as light was increased. In total darkness, the average length of the active period was 1.14 hours; for 9.5 hours of light, 0.62 hours; and for continuous light, 0.50 hours per active period. These data show that as the daylengths are increased, the amount and duration of activity decreases, but the frequency of activity remains rather constant. Activity is thought to consist of: (1) a feeding rhythm, and (2) a diel cycle that responds to light and temperature (Miller, 1955). It may be that the frequency of activity was controlled by hunger and the amount of activity by light in these experiments.

Activity, although decreased by light, is quite evenly distributed over a 24-hour period of alternating light and darkness (see Fig. 2). The manner in which light serves to reduce activity, even during the night, is not known. Figure 1 suggests that there were approximately seven periods of intense activity in total darkness. Perhaps the noise produced by active animals served to stimulate activity in others, and under natural conditions the periods of activity of different animals would not occur in synchrony. Miller (1955) in his laboratory studies on the bank vole and wood mouse, has shown that with decreased daylength there was a decreased amount of activity, and both species showed nocturnal rhythms with alternating periods of light and darkness.

Whereas males in my tests averaged more periods of activity for all three



FIGS. 1 to 3.—The distribution of activity of varying lemmings (2 males, 2 females) in response to different daylengths for each quarter-hour interval of the day. Each bar is the average amount of activity of 4 animals for a five-day period (in per cent for each quarter-hour interval of the day). 1: The average amount of activity, expressed in per cent, for total darkness. 2: The average amount of activity, expressed in per cent, for 9.5 hours of normal daylight. Photo period began at 7:15 AM and ended at 4:45 PM, shown by horizontal bar. 3: The average amount of activity, expressed in per cent, for continuous light.

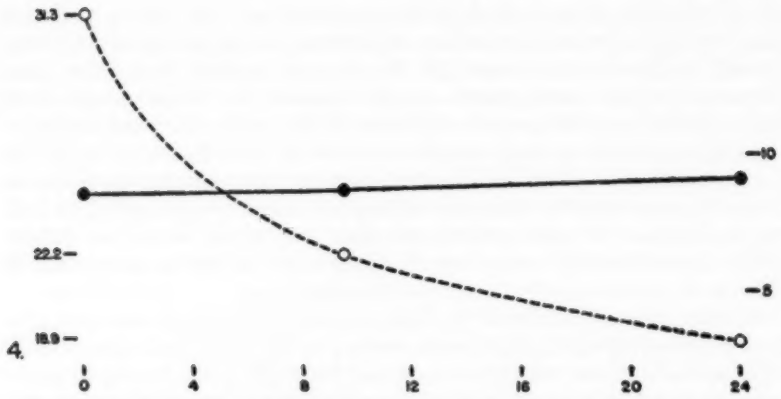


FIG. 4.—The frequency (solid line) and amount (broken line) of activity in relation to length of photo period (0, total darkness; 24, continuous light). Broken line represents the average amount of daily activity in relation to daylength, expressed in per cent. Solid line represents the average number of active periods per day in relation to daylength.

experiments, the average amount of activity was higher for females. As the photo period increased, the average frequency of activity decreased for males but increased for females. The average amounts of activity decreased for both males and females as the amount of light increased. Female No. 2 was irregular and her record shows that in continuous light she was most active, least active for normal day length, and intermediate for total darkness.

The role of activity has not been emphasized in regard to population fluctuations. Calhoun (1952) stated that as a population of rats increases in density, there is an increased frequency and complexity of behavioral adjustments. An increase in amount of activity in a population could, in effect, have the same results as increased density of populations. Miller (1955) has indicated that activity may be critical in both interspecific and intraspecific relations at certain times of the year in the wood mouse and bank vole. When increased activity and density in population occur together, the frequency of contacts would be extremely high. According to Christian (1950) this would be a period when "stresses" are maximal, and the animals begin to succumb with symptoms of exhaustion of the adreno-pituitary mechanism.

Summary.—Under laboratory conditions and constant temperature, increased length of daylight decreased the amount of activity in varying lemmings. The frequency of active periods remained rather constant although the average duration of each active period decreased with increased daylengths. During periods of alternating daylight and darkness the animals showed no significant nocturnal rhythms. It is suggested that the activity of varying lemmings in the Arctic may be increased during the periods of low light intensities, which may increase intraspecific contacts.

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FACTORS AFFECTING THE PROCUMBENCY OF RODENT UPPER INCISORS

BY STUART O. LANDRY, JR.

The angle at which the upper incisors protrude from the rostrum varies a good deal among different genera of rodents. By contrast, the variation of the degree of procumbency of the lower incisors is much less. It is as though rodents evolved a stable lower incisor form and variously adapted the upper incisor and rostrum to fit it.

The difference in the degree of upper incisor procumbency between forms is subjectively obvious. The incisors of a porcupine, for example, project much farther forward from the rostrum than do those of a squirrel. Objective measures of this incisor procumbency, however, are difficult and analyzing the factors that are responsible for differences between forms, more difficult still.

I first became interested in the problem of the development of different degrees of upper incisor procumbency among rodents while examining series of the African burrowing genera *Cryptomys* and *Heliophobius*. These animals

have the most extreme development of procumbency in the upper incisors of any rodent. Not only do the incisors project far forward from the rostrum, but the roots have extended far back into the skull, reaching to a point behind the cheek teeth. At the opposite end of the scale of upper incisor development we may place such forms as the squirrels and beavers with short, sharply recurved incisors.

The purpose of this paper is to analyze the mechanical factors involved in the evolution of these different incisor forms.

ACKNOWLEDGMENTS

Most of this work was done at the Museum of Vertebrate Zoology, Berkeley, California, and I am indebted to the authorities of that institution for the use of specimens of *Cryptomys*, *Thomomys*, and *Neotoma*. My thanks are also due to Dr. William Elder of the University of Missouri for the use of a series of *Sciurus niger* from the collections of the Zoology Department. Finally, I am indebted to Dr. Seth Benson of the Museum of Vertebrate Zoology for much stimulating discussion on the structure of rodent incisors. However, this is not to impute to him responsibility for any of the opinions contained herein, which are my own.

METHODS AND RESULTS

Oldfield Thomas, in a series of papers (1916, 1918, 1919), suggested that the degree of incisor procumbency in rodents might be expressed as the angle that the chord of the curved anterior surface of the exposed tooth makes with the plane of the occlusal surfaces of the cheek teeth. The surface of the cheek teeth is in approximately the same horizontal plane as the rostrum and forms a convenient datum plane from which to measure by eye. Thomas' method (1919) as it eventually evolved, was to measure the chord from the point at which the anterior surface of the incisor enters the alveolus to the tip of the incisor and to estimate the plane of the cheek teeth by eye, reading the angle between the two directly from a goniometer (Fig. 1).

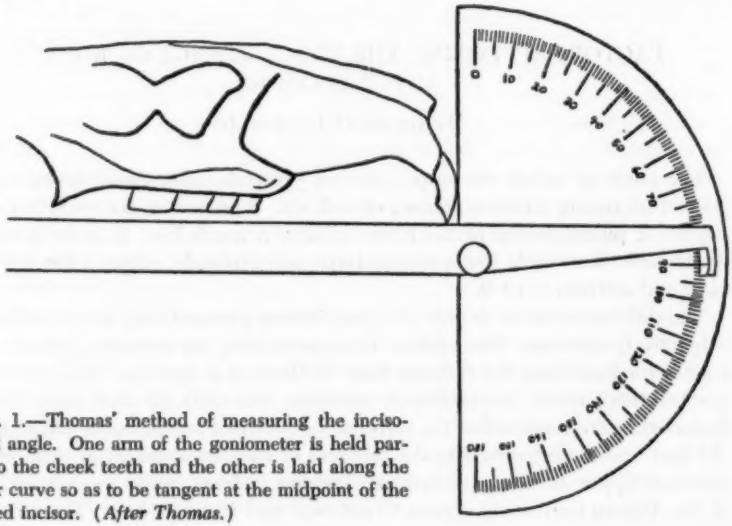

FIG. 1.—Thomas' method of measuring the incisorostral angle. One arm of the goniometer is held parallel to the cheek teeth and the other is laid along the incisor curve so as to be tangent at the midpoint of the exposed incisor. (*After Thomas.*)

Judging from the figure, what Thomas actually must have done was to estimate the midpoint of the exposed incisor curve and to take the tangent at that point as one side of his angle. Theoretically, this should have been less accurate than the stated method, but in practice it makes little difference. He noted (1916) that ". . . specimens with properly developed incisors, neither pulled out nor pushed in, are necessary, and it is also essential that the samples should be without imperfections in the bone at the point where the incisors leave it."

Thomas (1918) coined the terms "proodont" for rodents whose incisors were thrown forward more than 90° from the rostrum, "orthodont" for rodents whose incisors were at about 90° to the rostrum, and "opisthodont" for rodents whose incisors formed an angle of less than 90° with the rostrum. He called his measurement the "incisive index." I object to this name because it is not informative and since it has achieved little currency in the literature, I see no harm in changing it. I prefer to call Thomas' measurement the "inciso-rostral angle."

Thomas (1916) gave the inciso-rostral angle for some rodents as follows: *Rattus listeri*, 52°; *Rattus rattus*, 70–80°; *Rattus berdmorei*, "about 100°;" *Rhizomys*, 82–87°; *Nyctocleptes*, 97° or 98°; *Bathyergus*, "about 105°;" *Cannomys* 112–115°; *Heliophobius*, "about 130°;" "Canadian beaver," 90°; *Cynomys*, 95°; *Ondatra*, 96°. He gave no statistical treatment but did state that "a fairly large limit of error must be allowed."

When Thomas' method is applied to a large enough sample and statistics are calculated the results are surprisingly good. Twenty-nine specimens of *Sciurus niger* measured by Thomas' method showed an inciso-rostral angle that varied from 67 to 89° with a mean of 76.1°, a standard deviation of 4.3°, and a standard error of the mean of .80°. This degree of exactness is certainly adequate for the comparison of adaptive modifications of the incisor in different lines of rodents. The inciso-rostral angle is a useful measure and has the advantage, moreover, that it can be measured on drawings and photographs as well as skulls.

I did not measure the inciso-rostral angle in this investigation because I do not think the measurement gives enough information and it may be misleading. The inciso-rostral angle tells us roughly how much the incisors project forward, but it does not permit us to analyze the factors that are responsible for the procumbency. The method of measurement depends upon the amount of exposed incisor and this may be affected by factors having nothing to do with incisor procumbency. An erosion of the premaxilla would place the point at which the incisors enter the skull farther back and increase the inciso-rostral angle without actually affecting the procumbency of the incisor. It seems to me that any profitable analysis of incisor procumbency in rodents must consider the whole length of the incisor.

The procumbency of the upper incisor will depend, first, upon its curvature and, second, upon its position in the rostrum. The curvature of the incisor may be changed in two ways. The first is by bending, that is, by altering the radius of curvature. If the length of the incisor remains constant, the angular measurement of the arc will be inversely proportional to the radius of curvature of the incisor. As the radius of curvature approaches infinity, the angular measurement approaches zero and the curve of the incisor approaches a straight line. Hinton (1926) referred to proodont incisors as ". . . forming smaller segments of larger circles," which says the same thing.

The second way by which the incisor curve may be altered is by change in incisor length. If the radius of curvature is constant, more flattened incisors may be produced by shortening and more recurved incisors by lengthening them. Hinton takes no account of the effect of change in incisor length upon proodonty or opisthodonty in rodents. He apparently considers change in radius of curvature the only factor in change in incisor curvature.

Incisor curvature is not synonymous with incisor procumbency. The incisor could be projected or recurved simply by moving it in the rostrum without changing either the length or curvature of the incisor. However, I do not believe that simple change in position of the incisor has been very important in the evolution of proodonty and opisthodonty in most rodents. The position of the cutting tips of the incisor would tend to remain in the same plane whatever the degree of procumbency of the incisors. Rodent mouths are not designed

to open very wide so that, although the point of occlusion of the incisors might move backward and forward in the various adaptations, there can be little tendency for it to move up or down. Any vertical movement of the occlusion point would involve extensive modifications of the height of the cheek teeth and of the jaw joint.

With the cutting tips of the incisors adaptively fixed in one plane, the only way in which the incisor can be moved in the course of evolution to affect the angle at which the incisor projects forward from the rostrum (if the incisor lengths and angles of arc are constant) is to raise or lower the posterior end of the incisor. In most rodents the incisors are so large, relative to the size of the rostrum, that little movement of this sort is possible. I think, therefore, that while shift in position of the incisor in the rostrum undoubtedly does affect the procumbency of the incisor, the effect must be slight compared to that of change in the curvature.

This reasoning applies to rodents only. In lagomorphs, where the incisors are short and the rostra large, probably most of the difference in incisor procumbency between forms is due to shift in incisor position.

In the following discussion, the incisors are assumed to be arcs of a circle. The curvature of the incisor is determined by the pattern of growth in the first millimeter or so of tooth length. The tooth beyond this point is, for all practical purposes, dead. No additional material is laid down and none absorbed, beyond the growing end. Conceivably pressure from the structures surrounding the tooth alveolus might distort the incisor shape, but this seems unlikely for

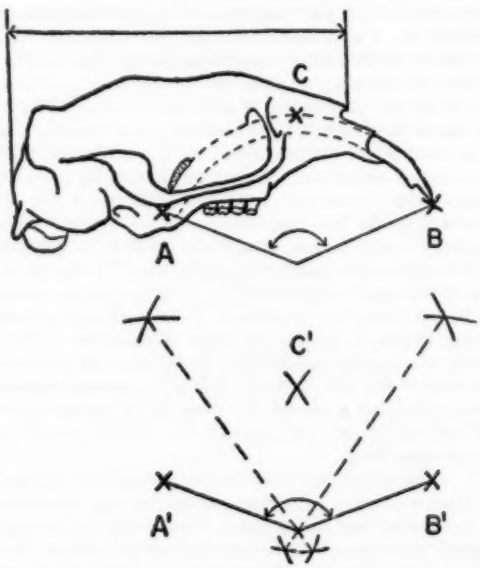

FIG. 2.—*Cryptomys* sp. (MVZ 117795) showing method for finding angular measurement and radius of curvature of rodent incisors. Points *A*, *B* and *C* are located on the skull as shown above. Points *A'*, *B'* and *C'* represent the same points transferred to a sheet of paper (below). The dashed lines on the sheet of paper are the perpendicular bisectors of *A'C'* and *B'C'*. Their intersection point is the center of the circle of curvature of the incisor. See text for details.

enamel is quite inelastic and, besides, the bony structures of the rostrum are not nearly so strong as the incisor.

Curvature, then, is produced by the difference in growth rate between the dorsal and ventral surfaces of the incisor. The incisor curves down because the enamel above is laid down faster than the dentine below. As long as the ratio between the growth rate of the enamel and that of the dentine remains constant, the curve produced will be a circle. Only if the rate of production of either substance, relative to that of the other, changes will there be a deviation from circular curvature, and then only during the change in ratio, *i.e.*, when one growth rate is accelerating or decelerating.

This has nothing to do with the absolute rate of incisor production, which could conceivably increase or decrease with available nutrients, breeding condition, or maturation. Indeed, the findings tabulated by Howard and Smith (1952) show a considerable variation in incisor growth in one species (*Rattus norvegicus*).

The curve of the incisor is not, strictly speaking, a circle, however. The incisor curves in three dimensions. Not only does the dorsal side grow faster than the ventral, but the lateral side grows faster than the medial so that the curve produced is not a flat circle but a shallow spiral, or more properly, a helix since the diameter does not change at each successive level. The helical shape of the incisor can be seen especially well in cases of malocclusion—see, for example, Fig. 27 in Hamilton (1939). In this picture the right incisor seems to be following the normal path of curvature and has displaced the left incisor laterally. The consequences of the assumption that the rodent incisor is an arc of a circle, although actually it is an arc of a helix, will be discussed below.

I selected the four genera *Sciurus, Neotoma, Thomomys,* and *Cryptomys* as typical of four different incisor adaptations: *Cryptomys* with extremely long, procumbent, proodont incisors; *Thomomys* with shorter, moderately proodont incisors; *Neotoma* with slightly recurved incisors; and *Sciurus* with strongly recurved, opisthodont incisors. The incisors of *Thomomys* of the "*bottae* group" are somewhat more procumbent than those of the "*talpoides* group." The species used in this investigation was *bottae.*

I attempted to compare series of animals from restricted areas to minimize the effect of geographic variation, but I was not always able to do this. In order to get a statistically useful series of *Cryptomys,* I was obliged to combine series showing a distinct size difference from the Cape Province and the Transvaal. Otherwise I used a series of *Neotoma cinerea pulla,* mostly from Siskiyou and Humboldt counties, California, a series of *Thomomys bottae bottae* from Santa Clara county, California, and a series of *Sciurus niger rufiventer* mostly from Boone county, Missouri.

The angles of arc represented by the incisors of these rodents were measured in the following way (see Fig. 2). Using a compass, the distance between the tip of the incisor (Point *B*) and the back end of the outside curve (enamel covered surface) of the incisor (Point *A*) was measured and marked off on a sheet of paper (Fig. 2, *AB* and *A'B'*). Next, a point *C* was marked on the upper edge of the incisor alveolus showing on the side of the skull (Fig. 2, *C*). The compass was adjusted to the width *AC* and an arc struck off on the paper from point *A'*. The compass was then adjusted to the width *BC* and an arc struck from point *B'* on the paper. The crossing of these two arcs is point *C'* on the paper, corresponding to point *C* on the skull. In Fig. 2, *AC* and *BC* are represented as equidistant, but they need not be.

The lengths *A'C'* and *B'C'* on the paper were chords along the arc of the incisor curvature. A theorem of plane geometry states that the perpendicular bisectors of two chords of a circle will meet at the center of the circle. Without bothering to draw in lines *A'C'* and *B'C'* on the paper, I struck off the necessary arcs from points *A', B',* and *C'* to erect the perpendicular bisectors of *A'C'* and *B'C'* (dashed lines in Fig. 2). The intersection of these bisectors was the center of the circle of arc of the incisors. Lines were drawn on the paper connecting the center with points *A'* and *B'* and the angle between these lines measured with a protractor.

By transferring the three points *A, B* and *C* from the three-dimensional helical incisor to a sheet of paper as *A', B'* and *C'* and constructing a circle from them, we have assumed that

all of the points along the helical incisor would fall along a circle if they were projected onto one plane. If a helix is projected onto a plane perpendicular to the axis of the helix, the result is a circle whose center lies along the axis of the helix. Here, however, we have transferred points along a helix onto a plane that forms an angle with the perpendicular plane, a plane determined by the three arbitrary points along the helix, *A*, *B* and *C* that we have selected. The three points which we have transferred to the paper actually lie along a somewhat elliptical curve, although it is not a true ellipse. However, the pitch of the helix of a rodent incisor is low and points *A*, *B* and *C* are relatively close together, along the helix, so that the plane upon which the curve is projected is not at a very great angle to the perpendicular plane. The error arising from the assumption that *A'*, *B'* and *C'* lie along a circle, therefore, is negligible.

I have checked the above assumptions by tracing the outline of incisors removed from the skulls of porcupines and beavers, finding the center of curvature by the above method and striking off a circle from the calculated center. The circle fits over the incisor curve through most of its length but the curve falls away from the circle slightly at the ends.

The above procedure gives only a rough measure of the angle of arc of the incisor. The most serious difficulty is that it is not always easy to find the back end of the incisor (Point *A*). *Cryptomys* presents no difficulties, but the incisors of *Sciurus* are buried deep in the rostrum and it is often necessary to guess the exact point at which they end. By observing the position of the incisors in broken skulls, it is possible to attain a fair proficiency at estimating the end point of squirrel incisors, but these estimates are certainly quite rough. It is extremely difficult to avoid bias under these conditions. However, I do not believe that bias was responsible for the difference in measurement between *Sciurus* and other forms. My tendency was to underestimate the length of squirrel incisors. As will be seen later, this error was on the conservative side, that is, it tended to cut down the difference between *Sciurus* and *Neotoma*.

In addition to this hazard, the tip of the incisors (Point *B*) may vary in position as there may be a varying tendency for the incisor to pull out of or slip down into its alveolus as the connective tissue at the growing end dries and shrinks. Both point *A* and *C* are estimated from outside the incisor alveolus, while point *B* is measured directly on the enamel.

The final, and perhaps most important, source of error is mechanical; errors resulting from the fact that pencil lines have thickness, that rulers slip or curve, that compass pencils loosen and push up and that the eye and hand of the investigator are fallible. The smaller the incisor, the more critical will these mechanical errors become. I estimated that in *Neotoma* I could only measure the angle of arc to within about 10°. This approximation, however, is good enough. If a large enough sample is used, even very rough measurements will yield quite accurate estimates of a mean, provided that the inexactitudes are random so that they tend to cancel out. Any individual measurement may be far off, but the mean of any inexact measurements will be quite accurately estimated. This is the important corollary of the statistical fact that the standard error of the mean of a sample is much smaller than its standard deviation.

Figure 3 shows the mean angle of arcs calculated from series of 43 *Sciurus*, 46 *Neotoma*, 37 *Thomomys*, and 33 *Cryptomys*. In this, and all subsequent graphs, the horizontal line represents the range of the sample, the vertical line the mean, the clear rectangle ± 1 standard deviation, and the solid rectangle ± 2 standard errors of the mean.

The series include both adult and juvenile animals. I assume that there would be no change in procumbency of incisors in a species during ontogeny and this is apparently true. A comparison of 13 juvenile *Cryptomys* with 19 adults shows mean angles of the arcs of 150° and 155°, respectively. The standard error of the difference is 2.85 and thus the difference is less than twice its standard error and not significant. These are rather small samples, however, and larger numbers might reveal a small significant difference between adults and juveniles, but hardly one large enough to affect the conclusions of this paper.

A juvenile was defined as any rodent, all of whose cheek teeth were not functional. This is not a very good definition since it admits to adulthood some very young animals, but it was the best age criterion that could be applied to all four of the species.

Figure 3 shows, as Hinton (1926) said, that the more procumbent the incisors, the smaller the angle of arc. The difference between *Neotoma* and *Thomomys* in angular measurement of incisor arc, though small, is significant. The difference between the means is 5° and the standard error of the difference is 1.86°. The difference is thus 2.69 times its standard error. The probability of this difference being due to chance alone is just under 1 per cent.

The important point, however, is not that the difference exists, but that it is so small. We should not expect to see rodents whose degree of incisor procumbency is as different as between *Neotoma* and *Thomomys*, show such a slight difference in angular measurement, if Hinton's generalization is true.

The radius of curvature may be taken from the same sheets used in measuring the angles of arc by measuring the distance from the center of the circle to points A', B', and C' (Fig. 2). Knowing the radius and angular measurement, to get the incisor length it is only necessary to multiply the radius by 2π, multiply the resulting figure by the number of degrees of arc, and divide by 360, thus:

$$L = \frac{\text{degrees of arc}}{360°} \times 2\pi r$$

The occipito-nasal length was used as the measure of skull length because it is not affected by changes in the shape of the upper incisors. As I measured it, it is shown in Fig. 2 running from the most posterior point of the supraoccipital (usually a bulge above the foramen magnum) to the anterior end of the nasals.

These length measurements were taken on adult skulls only, as defined above, and means, standard deviations, and standard errors of the mean were calculated. The sample sizes were thus reduced to 43 *Sciurus* (all were adults), 36 *Neotoma*, 23 *Thomomys*, and 19 *Cryptomys*. This reduction in sample size increases the standard deviations and standard errors of measurements, but not enough to seriously interfere with the conclusions of this paper.

In order to make any useful comparisons of these linear measurements, it is necessary to reduce them to a common standard. I did this by calculating what the incisor length and radius of curvature would be if the average skull length (occipito-nasal length) of all four were the same as that of *Cryptomys*, the smallest. Thus, for example:

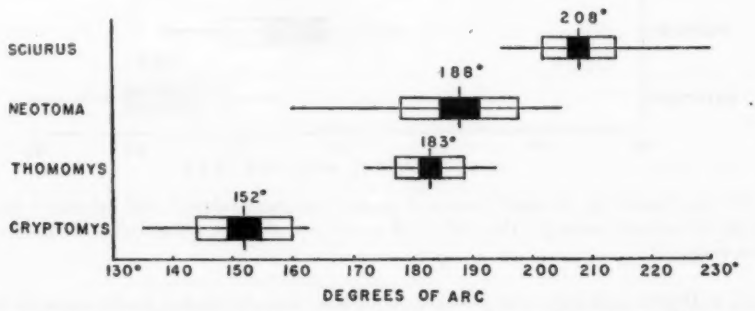

FIG. 3.—Graph of measurements in degrees of the arc of a circle represented by the incisors of four genera of rodents. The horizontal lines represent the ranges of the samples; the vertical lines, the means; the clear rectangles, ±1 standard deviation; and the solid rectangles, ±2 standard errors. The difference between *Neotoma* and *Thomomys* is significant (see text).

$$\text{Calculated } r \textit{ Sciurus} = \frac{\text{skull length } \textit{Cryptomys}}{\text{skull length } \textit{Sciurus}} \times \text{measured } r \textit{ Sciurus}$$

Figure 4 shows graphs of the incisor lengths and radii of curvature calculated in this way. The mean measurements were calculated as above and the other statistics of the absolute measurements transferred to the new means.

Note that in both calculated incisor length and calculated length of radius of arc *Neotoma* and *Thomomys* are quite far apart.

Note also that *Sciurus*, which according to Hinton's generalization should have the shortest radius of curvature, actually has a longer radius than does *Neotoma*, which has less recurved incisors. The difference between the radii of curvature is significant, the standard error of the difference being .087 mm. and the difference between the means being .6 mm. *Neotoma* also has the shortest incisors, significantly shorter than those of *Sciurus*, although *Neotoma* is a relatively orthodont form.

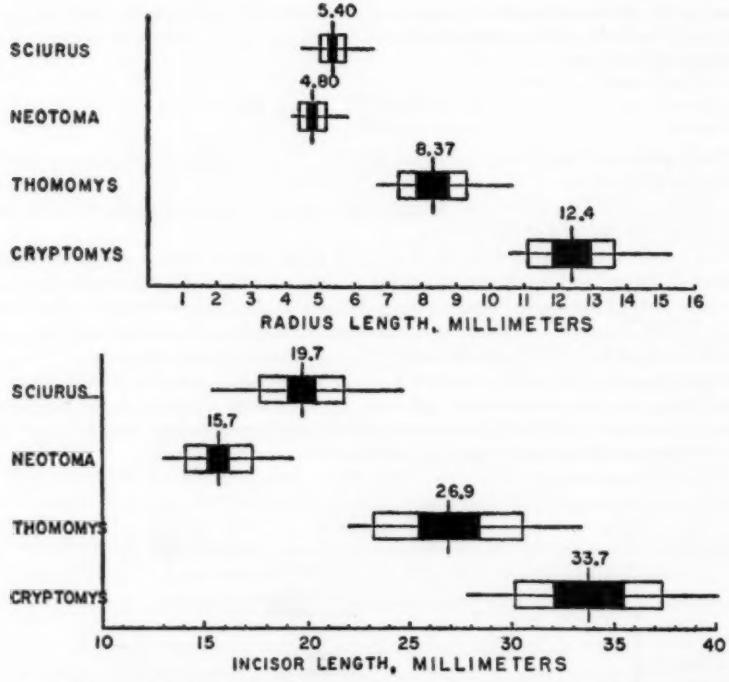

FIG. 4.—Graphs of calculated lengths of radii of curvature (above), and calculated total lengths of incisors (below), if the skulls of all genera were the size of the skulls of *Cryptomys* (see text).

If, as Hinton suggested, more proodont forms have incisors forming smaller segments of larger circles, the best measurement for rating proodonty should be the number of degrees of arc per mm. of calculated radius length.

$$\frac{\text{Angle of arc}}{\text{Calculated radius length}}$$

As incisors become more proodont, the numerator of this fraction should decrease and the denominator increase. This fraction would reflect both the influence of change in radius of curvature and change in length of the incisor, but change in the radius would affect both the numerator and the denominator and would thus exercise the greater influence.

In order to statistically analyze this fraction, it is necessary to calculate what the radius length of every individual rodent would be if all individuals were the same size as the average *Cryptomys*, and divide these individual calculated radii into the corresponding angular measurements, averaging the fraction for each species and calculating the standard deviations and errors.

Figure 5 shows a graph of this ratio with its calculated statistics. There is no significant difference in this ratio between *Sciurus* and *Neotoma*. The difference between the means is .9°/mm. and the standard error of the difference between the two means is .556°/mm. The probability that the difference between the two means is due to chance alone is about 10 per cent.

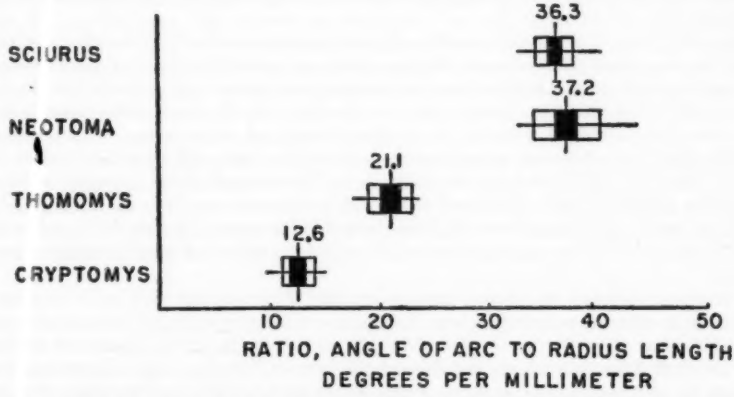

FIG. 5.—Graph of ratio of angle of arc of incisor to length of radius of curvature, the radius length being calculated as if all skulls were the same length as that of *Cryptomys* (see text). The difference between *Sciurus* and *Neotoma* is not significant.

DISCUSSION

Hinton's generalization does not always hold because it is based on the assumption that changes in incisor procumbency depend primarily on change in the length of radius of curvature. *Neotoma* and *Thomomys*, whose upper incisors differ considerably in degree of procumbency, fall very close to each other in angular measurement of the arc of incisor.

In *Thomomys* the radius of curvature of the incisor has increased considerably over that of *Neotoma* and if the length of the incisor had remained constant, the angular measurement of arc would have decreased, but the length of the incisor has correspondingly increased. The radius of curvature of *Thomomys* is 1.74 times that of *Neotoma*, while the length of the incisor of *Thomomys* is 1.71 times that of *Neotoma* (Fig. 4). The two opposed effects on the angular measurement almost exactly cancel out.

No such cancellation is seen in comparing *Cryptomys* with *Neotoma* because here the increase in length of radius proportionally exceeds the increase in length of arc. The calculated length of the radius of the incisor of *Cryptomys* is 2.58 times that of *Neotoma*, while the calculated length of the incisor of *Cryptomys* is 2.15 times that of *Neotoma* (Fig. 4). There is, therefore, a net decrease in angular measurement of the incisor arc.

Similarly, the length of arc of the incisor of *Cryptomys* is 1.25 times that of *Thomomys*, while the length of the radius of curvature of the incisor in *Cryptomys* is 1.47 times that of the incisor in *Thomomys*. The angular measurement of the incisor of *Cryptomys*, therefore, is less than that of *Thomomys*.

We can confirm our conclusion that the similarity between *Neotoma* and *Thomomys*, in angular measurement of arc, is due to compensatory increase in the length of the incisor of *Thomomys* as the incisor radius of curvature increases, by comparing, in the two genera, the ratio "degrees of arc of incisor *per* mm. of calculated radius length" (Fig. 5). Increase in length of the incisor does not affect this ratio as much as increase in radius of curvature, and we see that in *Thomomys* and *Neotoma* the values are quite different.

We may conclude, therefore, that adaptation for an increase in incisor procumbency from a more or less orthodont form, involves both increase in length of the radius of arc of the incisor and increase in the length of the incisor. A progressive decrease in angular measurement, as the incisor becomes proodont, may not always be evident, for the decrease in angular measurement produced by lengthening the radius is partially offset by the lengthening of the incisors.

Increase in length of incisors actually reduces proodonty and we may wonder why proodont incisors should be lengthened. The greater the pressure applied to the tip of an incisor, the more advantageous is length, for a long incisor gives greater surface inside the alveolus to increase the friction of the tooth against the alveolar wall. The force of the thrust is thus partially dissipated before it reaches the tender growing end of the incisor. This reasoning implies that proodont incisors transmit more thrust to their back ends than do orthodont incisors. Hinton (1926) stated that proodont forms "have abandoned to a greater or lesser extent the gnawing habit." This would imply that less force is applied to the cutting tips in proodont forms. However, even if the force applied to the cutting tips was less, a relatively straight incisor would transmit to its back end more of the force than would a highly curved incisor.

Increase of friction of the incisor along its alveolus, therefore, may well be an important reason for lengthening proodont incisors, but it seems to me that another factor may be even more important. If a short tooth were proodont, much of its length would have to be outside the skull if the incisor were to project as far forward from the skull as most proodont incisors do. A great leverage would be applied to the top and bottom of the incisor alveolus every time the tip of the upper incisor was pressed against the tip of the lower. The animal would tend literally to pry itself apart. This unfavorable mechanical advantage would be eliminated if the incisor were lengthened, so that most of its length was inside the skull.

The progressive changes in curvature and length of incisors, as they go from proodonty to orthodonty, are not continued as incisors go into opisthodonty. Although *Sciurus* does show a greater angular measurement of the incisor than any of the other forms, its calculated radius of curvature is actually 1.12 times as large as that of *Neotoma* (Fig. 4). Increase of the radius of curvature of *Neotoma* would reduce the angular measurement of the incisor if its length remained constant. However, the calculated length of incisor of *Sciurus* is 1.25 times that of *Neotoma* so that increasing the length of the incisor of *Neotoma* to that of *Sciurus* would proportionately increase the angular measurement. There is, therefore, a net increase in angular measurement of the incisors of *Sciurus* over those of *Neotoma*.

The fact that there is no significant difference between *Neotoma* and *Sciurus* in the ratio of angular measurement of arc to calculated radius length indicates that there must be a maximum ratio of angular measurement to relative radius length beyond which it is not profitable to go.

Obviously, *Sciurus* achieves its greater curvature of the incisors over those of *Neotoma* by elongation of the incisors rather than by further decrease in radius length. This is probably because any further bending of the incisor would bring the back end too close to the cutting tip. An incisor that covered an angular distance of above 300° would obviously be beyond the point of usefulness, since the back end of the incisor would be out

in the mouth cavity. I suspect that the mean value angular measurement of incisor for *Sciurus* is near the top limit of this measurement for rodent incisors. The longest individual measurement in my series was 230°, but this high value may be the result of inaccurate measurement.

Even if it is true that reduction of the radius of curvature beyond a certain point is unprofitable, we must still explain why the radius of curvature of the incisor should actually increase in going from orthodonty to opisthodonty. I think that this again may be explained as a separation of the two ends of the incisor. Of two arcs of the same angular measurement, but different in length, the ends of the larger will obviously be farther apart than those of the smaller. If the calculated radius of curvature of the incisors of *Sciurus* were the same as that of *Neotoma*, the back end of the incisor might protrude into the mouth cavity. Slightly enlarging the radius of curvature might permit a greater angular measurement to be attained. Of course, increase in radius of curvature of a strongly curved incisor would be sharply limited by available space in the rostrum. Whatever the explanation, the radius of curvature of *Sciurus* increases proportionately as the angular measurement of its incisor arc increases over that of *Neotoma*. The angular measurement of arc of *Sciurus* is 1.11 times that of *Neotoma*, while the calculated radius of curvature of *Sciurus* is 1.12 times that of *Neotoma*. The ratio of the two (Fig. 5) therefore remains the same.

To summarize, we may say that in general, starting from orthodont form, proodonty is accomplished by increase in length of the radius of curvature of the incisor, while opisthodonty is accomplished by increase in length of the incisor.

I do not mean to imply by this that primitive rodent incisors were orthodont. Indeed, they were probably somewhat proodont. The long, rootless, evergrowing rodent incisor in developing from that of a primitive mammal must be turned forward in order to allow the root to grow back into the rostrum. The short, slightly curved proodont incisors of rabbits seem to me about what one would expect in a primitive rodent.

There is even some palaeontological evidence for this hypothesis. Matthew's (1910) figure of *Paramys delicatus*, the most primitive rodent that we know, shows rather proodont incisors compared to slightly more advanced ischyromyids figured in the same paper.

However, once the rodent incisor had enlarged so much that shifting its position in the rostrum was no longer a practical way of changing incisor procumbency, procumbency was determined by the angular measurement of the incisor arc. Adaptations for greater or less procumbency were thenceforth governed by the interplay of the two factors discussed above.

SUMMARY

Four genera of rodents were selected as representing four different types of upper incisor development: *Sciurus*, strongly recurved, opisthodont incisors; *Neotoma*, relatively straight, orthodont incisors; *Thomomys*, somewhat protruding, proodont incisors; and *Cryptomys*, greatly protruding, extremely proodont incisors.

The angle of arc of the incisors of a series of each of these rodents was measured by laying off chords along the arc of the incisor, transferring these lengths to a sheet of paper, and erecting perpendicular bisectors thereof, which intersect at the center of the circle of arc. Lines were drawn connecting this center with points representing the ends of the incisor, and the angle between the lines measured. Also measured were the radius of curvature and the length of the incisor. The occipito-nasal lengths of the skulls were measured and, for comparison, all of the linear measurements were adjusted proportionately to what they would have been if all the skulls of all the genera were the length of the

smallest, *Cryptomys*. The number of degrees of arc per millimeter of adjusted radius of curvature for each genus was computed.

From a study of these measurements, it is concluded that change from relatively straight incisors to more procumbent incisors is brought about principally by increase in the radius of curvature of the incisor, while change from straight incisors to strongly recurved incisors is brought about principally by increase in length of the incisor. The interplay of these two factors in rodent upper incisor adaptation is discussed.

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Dept. of Anatomy, Univ. of Missouri School of Medicine, Columbia, Mo. Received November 25, 1955.

REPRODUCTION IN THE AUDUBON COTTONTAIL IN ARIZONA

BY LYLE K. SOWLS

The Audubon cottontail, *Sylvilagus audubonii arizonae*, is a common mammal of the desert regions of southern Arizona. It is found from the lowest elevations in the state, about 100 feet above sea level in southwestern Arizona, to an elevation of about 4,000 feet above sea level on the slopes of the desert mountain ranges in southeastern Arizona.

This cottontail is found in the vegetational types classified by Nichol (1943) as: Creosote bush–atriplex desert, characterized by *Larrea tridentata* and *Atriplex canescens*; Palo verde–cacti desert, where palo verde, *Cercidium microphyllum*, and sahuaro, *Carnegiea gigantea*, are the dominant larger plants; and Desert–grassland, characterized by mesquite, *Prosopis juliflora*, yucca, *Yucca elata*, and a great variety of grasses. It is also found in several types of chaparral country where such species as scrub oak, *Quercus turbinella*, smooth sumac, *Rhus ovata*, jojoba, *Simmondsia chinensis*, and a variety of other shrubs form a dense cover.

In some parts of southeastern Arizona, at about 4,000 feet elevation, it is found in the oak woodland where Mexican blue oak, *Quercus oblongifolia*, Emory oak, *Q. Emoryi*, beargrass, *Nolina microcarpa*, skunk bush, *Rhus trilobata*, and manzanita, *Arctostaphylos pringlei*, are characteristic larger plants. In this vegetational type the Audubon cottontail is replaced by a larger species of cottontail, *S. floridanus holzneri*, which extends its range up into the forest of yellow pine, *Pinus ponderosa*. This species of cottontail sometimes occurs with *audubonii* in the lower fringe of the oak woodland.

The published literature on the desert cottontail is fragmentary. In late 1951 I began a study to determine the breeding season and litter size of the desert cottontail and to gather miscellaneous items on its life history. From December, 1951, to September, 1955, I collected 407 specimens for this purpose. Weights of some of these were obtained. The reproductive condition of the females was recorded and measurements of the testes of males were taken as an index to breeding condition. Aging of the specimens was accomplished by an examination of the epiphysis of the humerus as described by Hale (1949). Rabbits showing complete or almost complete closure of the epiphyseal cartilage were considered to be adults.

Body weight.—Weights of 127 adult Audubon cottontails ranged from 560 to 896 grams for males and from 562 to 956 grams for females. Males averaged 725 and females 860 grams. The distribution of these weights is shown graphically in Fig. 1. Weights of eighty-seven adult males were compared with weights of forty adult females (pregnant females were excluded) to determine whether females were significantly heavier than males. A "*t*" test showed that the females were heavier than males (calc. *t* 4.60, tab. *t* 2.62 at the 1 per cent level) and that the difference was highly significant.

The Audubon cottontail is one of the smaller members of the genus *Sylvilagus*. It is considerably smaller than the eastern cottontail which ranges from 700 to about 1700 grams (Allen, 1938; Elder and Sowls, 1942). The greater female weight is characteristic of both.

Sex ratio.—Numerous workers have given sex ratio figures for the eastern cottontail (Allen, 1938; Schwartz, 1942; Bruna, 1952; Majors, 1955). All have found the sex ratio among wild cottontails to be nearly even, varying by less than one per cent between the sexes. Of 407 specimens taken for this study, 213 were males and 194 females, showing a ratio of 110 males : 100 females.

Breeding season.—Two methods were used to determine the length and period of the breeding season: females were collected in all months and examined for pregnancy and lactation, and the testes of collected males were measured.

The reproductive status of 194 females collected during different months is shown in Table 1. Pregnant females were found in all months except September, October, November, and December. Lactating females were found during the same months as well as one collected in September.

Measurements of testes were taken and their volumes were computed from

these measurements. The volumes of the paired testes are plotted individually in Fig. 2, which also gives the monthly mean of testis volumes for ninety-four adult cottontails. These data indicate that an increase in testis size begins in December and testis size above 2,000 cubic millimeters prevails until September but drops to below 1,000 cubic millimeters in September.

The occurrence of pregnant or lactating females coincided closely with the indications of breeding condition in males as described above. Thus the breeding season for the Audubon cottontail in southern Arizona during the years of this study was about eight months, beginning in January and ending in late August.

Table 2 compares the breeding season of the Audubon cottontail with the

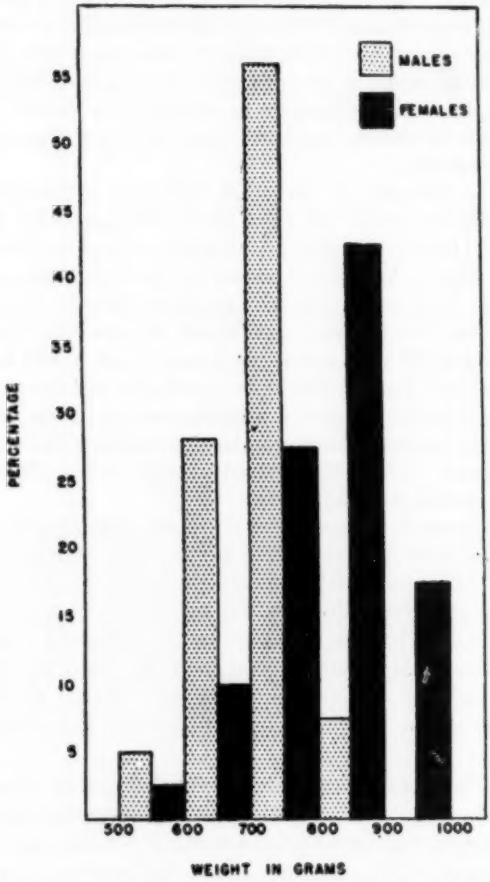

FIG. 1. — Frequency distribution of weights of 127 adult Audubon cottontails.

TABLE. 1. — *Reproductive status of 194 female Audubon cottontail rabbits collected during various months*

REPRODUCTIVE	NUMBER OF FEMALES COLLECTED BY MONTHS												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
Pregnant	3	9	7	11	6	7	8	5	0	0	0	0	56
Lactating but not pregnant	1	1	1	5	4	6	3	14	1	0	0	0	36
Pregnant and lactating	0	1	1	6	1	1	2	1	0	0	0	0	13
Neither pregnant nor lactating	8	3	0	1	6	10	14	9	11	9	16	15	102
Monthly Totals	12	13	8	17	16	23	25	28	12	9	16	15	194

breeding season of other species of the genus *Sylvilagus* as given in the literature. Although some variation is apparent between the findings of various workers, even on the same species in the same state, the data indicate that the Audubon cottontail in Arizona has as long a breeding season as any member of this genus which has been studied.

Breeding season and the weather.—The effects of seasonal weather changes, particularly rainfall and the resulting abundance of food, upon the reproductive seasons of the cottontail rabbit have been discussed by several writers. Fitch (1947: 170) says of the Audubon cottontail (*S. audubonii vallicola*) in central California, "Breeding is ordinarily limited to the late fall, winter, and spring months—the growing season when green forage is abundant. In rabbits trapped during the dry scason, the genitalia had retrogressed so that sex was not readily determined, and it was evident that breeding activity had ceased. The reproductive physiology may be controlled by the seasonal change in diet."

TABLE 2. — *A comparison of breeding seasons for various species of cottontails in the United States*

SPECIES	PLACE	MAIN BREEDING PERIOD	AUTHORITY
S. floridanus mallurus	Conn.		
S. floridanus transitionalis	Conn.	Mar.-Sept.	Dalke (1942)
S. floridanus mearnsi	Mo.	Mar.-Sept.	Schwartz (1942)
S. floridanus mearnsi	Mich.	Feb.-July	Allen (1938)
S. floridanus mearnsi	Mich.	Mar. 15-Aug. 15	Haugen (1942)
S. floridanus mearnsi	Mich.	Jan. 15.-Aug. 15	Trippensee (1936)
S. floridanus mearnsi	Wisc.	Mar.-Aug.	Hale (1949)
S. floridanus mearnsi	Penn.	Mar.-Sept.	Buele & Studholme (1942)
S. floridanus mearnsi	Ohio	Mar.-Sept.	Atzenhofer & Leedy (1947)
S. floridanus mallurus and *S. aquaticus*	Ala.	Feb.-Aug.	Majors (1955)
S. audubonii audubonii	Calif.	Dec.-June	Orr (1940)
S. bachmani	Calif.	Jan.-May	Mossman (1955)
S. audubonii arizonae	Ariz.	Jan.-Aug.	This study
S. audubonii audubonii	Calif.	All months	Ingles (1941)

Mossman (1955:178) found a similar correlation between the reproductive season of the brush rabbit (*S. bachmani*) in central California and the rainy season with resulting abundance of green vegetation.

In this study no clear correlation between reproductive season and rainfall was found. The reproductive season of the Arizona Audubon cottontail followed the season when winter rains usually fell, but in some years winter rains did not fall until after cottontail breeding had started. Also the reproductive season of the Arizona cottontail continued through the driest part of the year and ceased just when the lush vegetation following the summer rains was available.

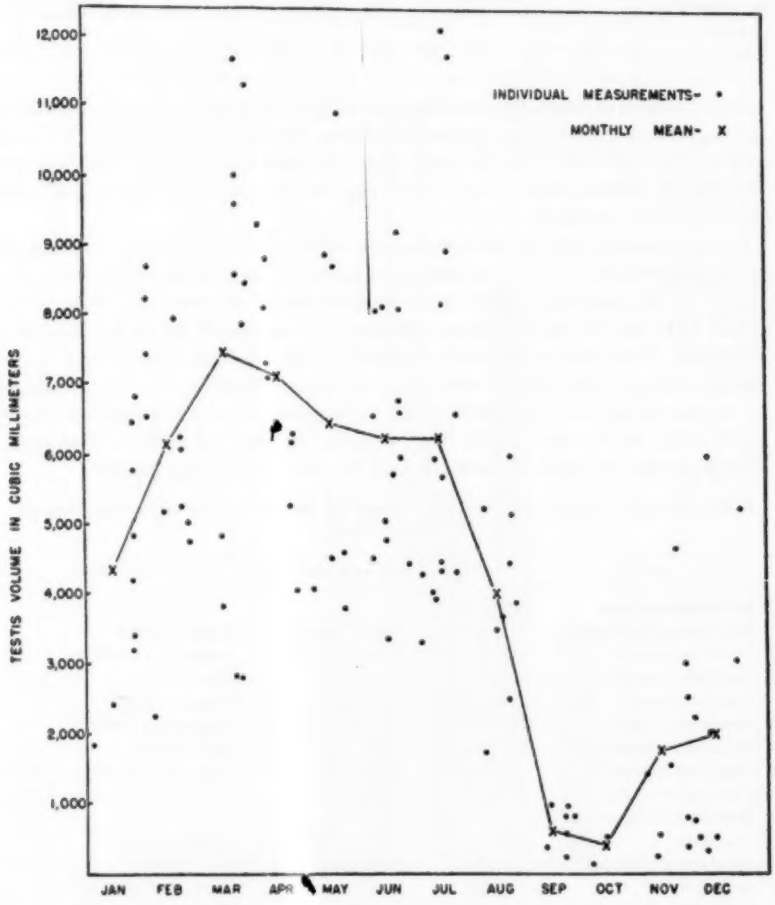

FIG. 2. — Individual and mean testis volumes for 94 Audubon cottontails collected during different months.

Thus information gathered in this study did not show a correlation between rainfall and breeding as other workers have so clearly demonstrated for California cottontails.

Litter size.—Of the 194 females represented in Table 1, 56 were pregnant. Of this group 18 (32 per cent) had two embryos each, 26 (46 per cent) had three embryos, and 12 (22 per cent) had four embryos. No females with fewer than two or more than four embryos were found. The mean number of embryos per pregnant female was 2.9.

Only one case of embryo resorption was found in this study. A pregnant female collected on April 8, 1954, had three live embryos and one partially resorbed embryo.

The average litter size for various species of *Sylvilagus* as reported in the literature is summarized in Table 3. In the present study all data on litter size was based on embryo counts. The studies reviewed from the literature were based both on embryo counts and on young found in the nest. These data show an average litter size of between four and five for all studies of the eastern cottontail, between three and four for all California studies, and below three for the Arizona species. Thus the average litter size of 2.9 found in *S. audubonii arizonae* is the smallest litter size found for any large sample of any species in the genus *Sylvilagus* which has been studied.

Factors compensating for low litter size.—The low litter size found for the Audubon cottontail in Arizona as compared with other members of the genus *Sylvilagus* indicates a lower reproductive rate than in other species of cottontail. High populations found during most of this study, however, indicate that

TABLE 3.— *A comparison of litter sizes in various species of cottontails in the United States*

SPECIES	PLACE	NO. OF RECORDS	RANGE IN LITTER SIZE	AVERAGE LITTER SIZE	AUTHORITY
S. floridanus mearnsi	Penn.	26	3–8	5.42	Buele (1940)
S. floridanus mearnsi	Mich.	12	4–7	5.4	Haugen (1942)
S. floridanus mearnsi	Mich.	11	4–7	5.1	Allen (1938)
S. floridanus mallurus	Conn.	25		5.0	Dalke (1942)
S. floridanus mearnsi	Ohio			5.0	Atzenhofer and Leedy (1947)
S. floridanus mearnsi	Penn.	64	2–7	4.95	Buele and Studholme (1942)
S. floridanus mearnsi	Mo.	40	1–8	4.4	Schwartz (1942)
S. floridanus mearnsi	Ky.		3–9	4.4	Bruna (1952)
S. floridanus mearnsi	N.Y.	22	2–7	4.5	Hamilton (1940)
S. floridanus mallurus	Va.	21	2–6	4.7	Llewellyn and Handley (1945)
S. bachmani	Calif.	26	2–6		
S. bachmani	Calif.	11		3.69	Mossman (1955)
S. floridanus mallurus and				3.5	Orr (1940)
S. aquaticus aquaticus	Ala.	36	1–7	3.1	Majors (1955)
S. audubonii arizonae	Ariz.	56	2–4	2.9	This study
S. audubonii cedrophilus	N. Mex.	2	2	2.0	Bailey (1931)

the low litter size is compensated for by other factors. One of these is the longer breeding season.

That a longer breeding season compensates for a low litter size for the Audubon cottontail in California has been pointed out by Ingles (1941). The eight-month-long breeding season for the Arizona cottontail is longer than that of any other member of the genus yet reported, except for the Audubon cottontail in California (Ingles, 1941).

Numerous workers have speculated on the number of litters per year which other species of cottontails are able to produce (Schwartz, 1942; Allen, 1938; Haugen, 1942; Ingles 1941; Majors 1955). Haugen found a six-month breeding season for Michigan cottontails, where four litters per season were not uncommon. Mossman (1955:182) believes that with a peak period of reproduction lasting from January through May, the California brush rabbit (*S. bachmani*) could easily have four litters per year, although he believes that three per season is a reasonable figure.

Having an eight-month breeding season, it seems plausible that the desert cottontail could produce one more litter per year than that found by Haugen or Mossman for other species of cottontails. Thus five litters per season for some Arizona cottontails seems possible. It is realized, however, that the occurrence of five litters per season is probably an exception, just as the four litters per year found by Haugen in Michigan and Mossman in California are also extreme cases and do not represent the actual figure for the entire population. At any rate, it seems logical to assume that the long breeding season in Arizona may be an important factor in compensating for the low litter size.

The low litter size for Arizona cottontails is further compensated for by early breeding of young rabbits during their first year of life. In spite of the research that has been done on the eastern cottontail, there are only scattered records of juveniles breeding during their first summer. In Iowa, Hendrickson (1947:63) reported that an eastern cottontail had six fetuses when about five months old. Cooley (1946:273–274) found two Michigan cottontails which bore young during their first year of life. Ingles (1942) found two Audubon cottontails in California which bore young before they were nine months old. That the early breeding of Arizona cottontails may be an important factor compensating for the low litter size was shown by the fact that of thirty-one females collected in July, August, and September, which showed evidence of breeding, eleven were juveniles which were either pregnant or had already borne young.

The approximate age of pregnant females was determined by an examination of the epiphyseal cartilage plate of the humerus, following the technique developed by Hale (1949). No accurate data exist on the rate at which the closure of the epiphysis occurs in Arizona cottontails. Hale (*op. cit.*: 222) found that complete closure of the epiphysis in Wisconsin cottontails occurred in eight and one-half to nine months. Majors (1955:85) found a similar period for cottontails in Alabama. Some Arizona rabbits collected during the late winter

and early spring which did not show complete closure of the epiphyseal cartilage were undoubtedly born during the late part of the previous year's breeding season. Those collected during June, July, and August which showed wide areas of epiphyseal cartilage were probably less than five months of age. This is further indicated by the fact that all rabbits collected in late winter and early spring showed complete or almost complete closure of the epiphyseal cartilage.

Assuming that Arizona cottontails develop as fast or faster than eastern cottontails, it is possible to determine the minimum number of cottontails collected which bred during their first nine months of life. Eleven of 31 females found in reproductive condition in July, August, and September were young born in the spring. Data on the reproductive condition of these juvenile females are given in Table 4. Thus the breeding of young during their first year of life may be important in compensating for the low litter size found in this southwestern species.

TABLE 4. — *Record of female cottontails breeding during first summer of life*

SPECIMEN NUMBER	DATE	EVIDENCE OF BREEDING
139	8-20-52	Lactating
219	7-3-53	Pregnant, 2 embryos
222	7-3-53	Pregnant, 2 embryos
250	8-7-53	Pregnant, 2 embryos
264	8-27-53	Recently lactating
267	8-27-53	Recently lactating
283	9-29-53	Recently lactating
428	8-6-54	Pregnant, 3 embryos
437	8-10-54	Pregnant, 4 embryos
440	8-10-54	Pregnant, 2 embryos
508	8-23-55	Recently lactating

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SUMMARY

1. The Audubon cottontail, *Sylvilagus audubonii arizonae*, is a common mammal of the desert regions of Arizona.

2. Between 1951 and 1955, 407 Audubon cottontails were collected to determine litter size and the length and period of the breeding season.

3. Sex ratios were found to be almost even; females were significantly heavier than males.

4. The breeding season of the Audubon cottontail begins about January 1 in southern Arizona and ends in late August.

5. No correlation between the breeding season and rainfall was found in southern Arizona.

6. The litter size ranged from two to four and averaged 2.9 embryos per pregnant female.

7. Of 31 female cottontails collected in July and August, either pregnant or lactating, eleven were less than nine months old. Age was determined by the closure of the epiphyseal cartilage plate of the humerus.

8. The low litter size is compensated for by the long breeding season and the breeding of juvenile females during their first year of life.

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INJURY TO AND RATE OF GROWTH OF AN ELEPHANT TUSK

BY SIR FRANK COLYER* AND A. E. W. MILES

The tusks of elephants are of continuous growth and are socketed into the upper jaw as shown in Fig. 1. The socketed portion is almost vertical and the growing end is situated just below the floor of the nasal cavity. This portion of the tusk contains a funnel-shaped pulp cavity the extremity of which in the adult animal reaches almost to the level of the margins of the bony socket. The relatively superficial position of the thin-walled socketed portion of the tusk on the face of the animal exposes it to injuries from bullets and spears aimed at the head from in front. Weighted spears dropped by natives from the branches of overhanging trees have been known to penetrate the open end of the tusk from above (Bland-Sutton, 1910). Many specimens are recorded which show the remarkable powers of the enormous pulp to recover from such injuries. The earlier literature has been reviewed by Miller (1890, 1891). Other specimens have been described by Busch (1890), von Metnitz (1903), Stannus (1911) and Colyer (1936). There have also been recorded a number of instances in which tusks have snapped off leaving the socketed portion *in situ* and in which a mass of ivory has been deposited in the pulp cavity sealing off the pulp from the external environment so that formation of the tusk has continued, though in a disturbed manner (Miller, 1891), Mitchell (1903), Humphreys (1926). The specimen described is of this character. It is part of the left tusk of an African elephant (*Loxodonta africana*) that remained in the jaw after the rest was broken off, together with a portion added after the injury. It was pre-

*Deceased.

sented to the Odontological Collection by Mr. B. Cooper who shot the animal in the Kondoa District, Central Provinces, Tanganyika Territories. Two years previously an elephant in this district was seen to fall into a ravine and break off one of its tusks which was subsequently recovered and found to be almost complete, weighing about 50 lbs., which is a common tusk weight for an adult male African elephant. It is very probable that the present specimen can be attributed to this animal.

This portion of tusk removed from the suppurating tissues of the jaw weighs 14½ lbs. as compared with a weight of 69 lbs. for the intact opposite tusk. The specimen has a total length of 57 cms. and consists of two parts, a distal one of about 23 cms. long (*A* in Fig. 2), and a proximal part (*B*) of about 34 cms. Each of these portions has the form of a hollow cylinder but *A* is slightly wider than *B* and overlaps it where the two meet. Only on the posterior surface of the tusk are these two portions continuous with each other. This continuity can easily be demonstrated by the removal of part of the portion *B* as shown in Fig. 2 where the two portions are seen to be joined by a large irregular mass of ivory. Several transverse sections were also made along the length of the tusk.

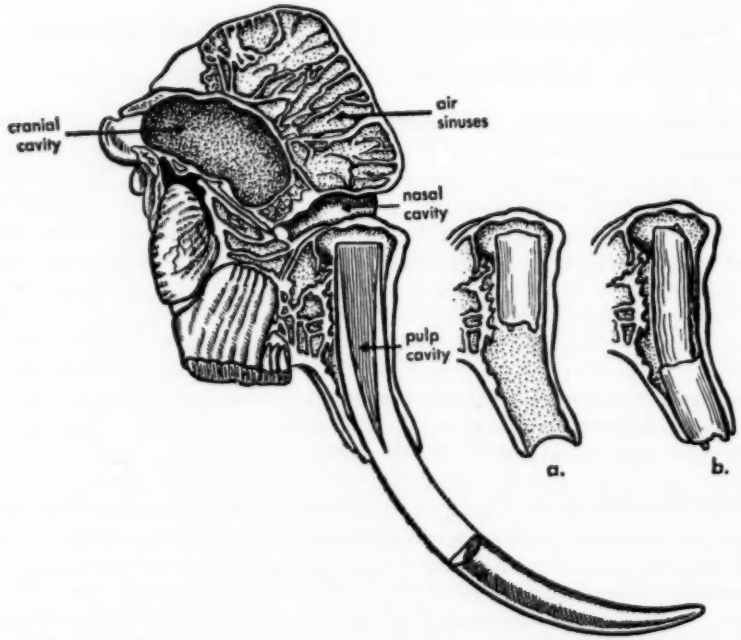
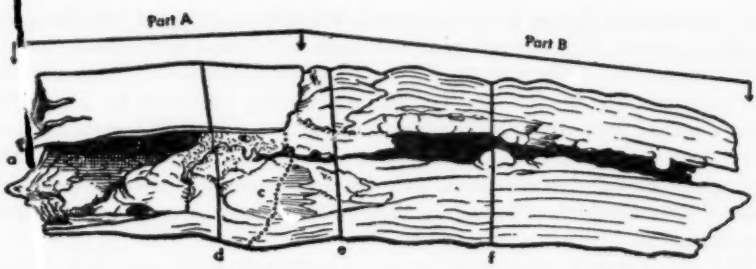


FIG. 1.—Longitudinal section through skull and part of tusk of an Indian elephant. After Owen (*Odontography*, Pl. 146). The inset diagrams show the probable condition of the tusk of the African elephane described, (*a*) immediately after the injury and (*b*) two years later.



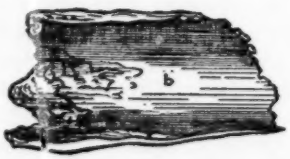


FIG. 2.—The anterior surface of the tusk, showing (*a*) jagged fractured end; (*b*) fragment of distal part of tusk that has been turned down to show inner surface and irregular mass of ivory; (*c*) dotted line indicating original position of fragment; (*d*, *e*, *f*) positions of transverse sawcuts.

Both parts of the specimen have the characteristic appearance of the growing end of a tusk. There can be little doubt that the portion *A* was the fragment of tusk originally left behind in the jaw after the rest had been broken off and that the jagged distal end of this part was the site of the fracture. Portion *B* must have been formed after the injury, gradually pushing *A* downwards until, to judge from the worn and stained appearance of the fractured edge, it projected slightly from the jaw.

It may be supposed that the greater part of the pulp in the original tusk fragment became necrotic as a result of the injury but that the formative tissues in the opening of the funnel-shaped extremity of the tusk survived. At first a mass of unorganised dentine was formed, nearly filling in the pulp cavity and bridging over the raw surface of the pulp. This is the mass of ivory joining the two portions; in section it was seen to have an irregular gnarled structure. Subsequently the formative tissues recovered and went on to form the portion *B* which, as the other transverse sections showed, had a structure which became progressively more normal. The abnormal longitudinal fissure shown in Fig. 2 can be attributed to the non-recovery of a small region of the formative tissue.

The principal interest of this specimen is that it shows once again the remarkable recuperative power of the pulp of the tusk of the elephant. This is of course contributed to by the enormous size of the pulp and by the fact that, as the tusk is of continuous growth, the pulp has a good blood supply through its wide base, whereas in teeth of limited growth the blood supply enters the pulp by a number of narrow canals through the closed end of the root.

A further point of interest is that, if the specimen in fact belonged to the animal that fell into the ravine two years previously, it provides evidence of the rate of growth of the tusk. Assuming that the weight of ivory added to the broken stump of tusk was not substantially less than that added to the tusk of

the opposite side during the same period, it might be expected that the combined weight of the specimen and the broken tusk found in the ravine would approximate that of the opposite side recovered at a later date. These weights are approximately 64½ lbs. and 69 lbs., respectively. Allowing for a possible loss of weight from drying of the specimen and various other factors, such as the influence of the trauma on the amount of ivory formed, these weights may perhaps be regarded as consistent with the circumstantial evidence which suggests quite strongly that the animal shot by Mr. Cooper was the one that fell into the ravine.

The rate of growth of elephant tusks is a matter on which very little data is available. Perry (1954), on the basis of a detailed study of the carcasses of a large number of African elephants, concluded that the rate of growth of the tusks is very variable so that their size and weight cannot be used to assess the age of animals. Pitman (1953) mentions that the tusks of adult male elephants may grow as fast as 5 lbs. per year or even more rapidly. The portion of the present specimen formed after the injury weighs 11 lbs.

The estimated rate of growth in the present specimen, namely 17 cms. per year or 3.3 mm. per week, corresponds very closely to that in a similar specimen described by Humphreys (1926) which is at present in the John Humphreys Odontological Museum of the Medical School, University of Birmingham. The specimen is the broken tusk of an Indian elephant and weighs 22 lbs. Twelve months after the tusk was fractured the animal was killed and the implanted portion showed a zone of grossly disturbed dentine formation 16 cms. from the proximal developing end, *i.e.*, 16 cms. were formed during the year that elapsed after the injury. This represents a rate of growth of approximately 3.1 mm. per week.

These rates of growth correspond closely with that of continuously growing incisors in other animals. The rate of eruption of the upper incisors, measured by noting at weekly intervals the position of a transverse notch cut on the crown, varies from 1.3 mm. per week in the porcupines, *Erethizon dorsatum* (Shadle, Ploss and Markus, 1944), to 4.3 mm. in the pocket gopher, *Thomomys bottae* (Howard and Smith, 1952), and is 2.1 mm. per week in rabbits (Shadle, 1936) and the rat, *Rattus norvegicus* (Shadle, Wagner and Jacobs, 1936). The rate of eruption of the lower incisors is consistently slightly greater than that of the upper. It is reasonable to assume that these rates represent at least approximately the rate of growth of the developing ends of the roots of the incisors.

Summary.—A specimen is described which represents the socketed portion of the tusk of an African elephant left behind after the rest had broken off. Very considerable growth had taken place after the injury, indicating the great recuperative power of the pulp of the tusk. If the circumstantial evidence that the injury occurred two years previously can be accepted, growth occurred at the rate of 3.3 mm. per week. This rate of growth corresponds closely to that in a similar specimen described in the literature and also with the rate of growth of incisors of continuous growth in other animals.

Acknowledgment.—We are grateful to Professor H. F. Humphreys for providing the data concerning the tusk in the John Humphreys Odontological Museum.

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OBSERVATIONS ON THE BEHAVIOR OF PENNED MULE DEER

BY LUDVIG G. BROWMAN AND PAUL HUDSON

A small herd of Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) was kept in an enclosure during the fall months of 1955 in order to secure known aged embryos. As a subsidiary project the behavior of this herd was observed. It was felt that this ancillary study would be useful to us and possibly to others for future use in handling confined mule deer.

This investigation was made possible through the cooperation of the U. S. Fish and Wildlife Service, Montana Fish and Game Department, Montana Cooperative Wildlife Research Unit, and the Research Council of Montana State

University to whom grateful acknowledgement is made. We are indebted to Artemus R. Davis for technical assistance during the project.

Materials and Methods—A corral at the National Bison Range, Moiese, Montana, was made available for this project. The corral was roughly 130 feet long by 45 feet wide, running in a NE-SW direction, with a partitioned area 23 feet from one end used as an isolation pen for the buck. A plank fence 7-8 feet high surrounded the entire enclosure. This fence and the partition fence were covered with burlap to a height of 7 feet leaving a gap of one foot at the base of the fence. An enclosed observation tower was built above one corner of the buck's pen overlooking the does' corral. The floor of this hut was about seven feet above ground level, and in it was kept all essential equipment.

Alfalfa hay and stock pellets were provided by the Montana Fish and Game Department. Hay was invariably fed first each morning, stock pellets were usually fed then also, and hay might be fed again in the late afternoon depending on the weather. An electric water heater kept the water tank open throughout the observations. A reading of –30°F. was recorded in the valley on November 16, 1955.

A few of the deer were collected by drives on the Bison Range; most were obtained through the activities of Cy Young and other Bison Range personnel who watched pastures, lanes, etc. for wandering deer and herded them into the proper enclosures. Observations from October 26 through December 25 were made on 13 does, two fawns and one mature buck.

A period of adjustment extended from October 17 through October 28. During this time Davis fed the deer and made a point of casually appearing in the pen at frequent intervals. The deer gradually quieted down and did not "spook" when he went into the corral. After the first ten days or so the buck was separated from the does with a minimum of disturbance. Three or four times early in the project a doe was left in his pen overnight. The buck soon learned to go to his pen when the observer appeared in late afternoon. At first he was accompanied into the isolation pen by nearly all the does, but gradually fewer of them dashed into his pen at this time. The observer stood behind the open gate (shielded by burlap covering) and enticed the does back out one by one until only the buck remained.

Detailed daily observations were begun on October 29 and terminated on December 23. The buck was always isolated from the does overnight. All observations on behavior were made between 8 A.M. and 4 P.M. At this latitude the average time of sunrise from October 25 through December 25 was 7:52 A.M., and the average time of sunset was 4:57 P.M. The behavior of each animal was noted at least once every hour during the day, often more frequently. The animal's exact location in the corral and its activity (bedded, standing, feeding, watering, etc.) at that moment were recorded hourly or more often on a chart outlining the corral. All deer were individually marked with lacquer symbols painted on the body, as well as with a combination of red, white or yellow plastic ear strips which were fastened onto the margin of the ears by means of metal numbered ear tags.

General movements.—The bulk of the daily movements, as revealed by plotting the movement of all individuals on charts, was between the hay lane along the north end of the east fence, the stock pellets in the north end of the corral, and the bedding sites along the east and south quadrants. Only infrequent visits were made to the water trough in the northeast corner. There was no pacing back and forth along any fence in the doe pen. The buck, however, did pace considerably along the closed gate whenever he was isolated. He joined the herd of does each morning and never paced while with them. The quiet behavior of these confined animals is believed to be largely the result of giving them "cover" behind the burlap-lined fences.

Use of water.—All the animals were observed to drink from the water tank, even when there was fresh snow on the ground. Most of the drinking seemed to take place from 8:30-10:00 A.M. Very little use was made of the water after 11 A.M. Over 75 per cent of the 250 recorded observations of drinking occurred before 11 A.M.

Feeding.—Most of the feeding took place immediately after the morning feed and in the late afternoon. However, there was some feeding at all hours of the day, with minimal activity during the middle of the day. Feeding on alfalfa hay was three times as frequently as on pellets during the first two hours. Dixon (1934) stated that "mule deer of both sexes normally do most of their feeding in the early morning or in the late afternoon," and our counts support this observation.

It is a widely observed fact that cattle seem invariably to be chewing the cud while lying down. However, in bedded mule deer only 32 per cent of 1465 recorded observations showed cud chewing. Among deer standing quietly, only 9 per cent were observed chewing the cud. It may be that it is during the hours of darkness that the animal does most of its rumination, as suggested by Tribe (Hammond, 1955). The few observations on does indicated chewing on the left side to be three times as frequent as on the right side, with an average of 54 chews per cud (range 47-62). McLean (1940) observed a mule deer buck chewing an average of 33 times per cud. Ten different observations of our buck yielded the average of 54 chews per cud. Linsdale and Tomich (1953) report an average of 52 chews per cud.

Bedding habits.—Very few deer were bedded down before 10 A.M. The peak of bedding behavior took place at mid-day, particularly from noon to 2 P.M. Dixon (1934) reported that mule deer spend the middle of the day bedded down, as does Darling (1937) for the Scottish red deer. During this nonactive period about two-thirds of the animals were bedded down while the others were standing quietly.

The bedding positions of different deer varied from time to time. For example, one deer bedded with her neck extended full length along the ground and with her eyelids closed; four bedded deer had their noses tucked into the groin; while seven others held their heads erect, ears folded back over the neck, and eyelids partly closed. At another time two deer bedded with their noses in their groins; twelve bedded with head erect, ears forward and eyes open;

while one stood with her neck approximately horizontal and eyelids closed. The bedded deer tended to face the observation hut (north) early in these observations, but as they became adjusted they gradually bedded facing random directions, e.g., at one time four deer headed north, five headed west, two headed south, and one east. The slope of the ground was so slight to the west that it apparently exerted very little influence on their bedding postures.

Different deer bedded for different lengths of time during the day, ranging from 31 to 70 per cent of the time observed. The average amount of time that individual members of the herd were bedded was 49 per cent of the period of observation. Individual deer tended to use different sections of the corral with each deer having its own preferred area. The herd generally bedded as a group with the animals fairly close to each other. However, individual deer did not tend to return to the precise bedding spot time after time. Some shifted bedding sites as many as five times during the observation period, particularly when the buck was active and "ran" the does. Darling (1937) reported that, in the Scottish red deer, "it is usual for most animals to change their positions at least once during a three or four hour rest.' The mule deer would bed near, but not necessarily in, the same sites on the same day. Some sections of the corral were used more frequently for bedding purposes than others; the quadrant which was near the water trough was never used. Three of the does and the two fawns were usually the first deer to bed down. Ordinarily, after the buck had inspected the corral, gone his morning round checking the does, and had a drink, he too would bed down before 10 A.M.

Social order.—An attempt was made to determine the order of dominance-subordinance among the does. It was felt that an objective criterion for determining dominance was the "kick-order"—that is, the frequency with which the does lashed out at one another with their front feet. All does and fawns gave way to the buck whenever he aproached.

It became evident that the deer had divided themselves roughly into three groups. Group 1 was recognized as the dominant group. The top of this social hierarchy was a doe who kicked eleven of the other thirteen does and was kicked by only one; this one, who seemed to be second in the social order, and a two-year-old were apparently sparring for second place—both kicked at least ten others, were kicked at by three others, and kicked each other with equal frequency. Group 2 or the sub-dominant group included two does who kicked at least four others and were kicked by only two others, but were never observed to kick each other. These does seemed willing to move aside with little or no insistence upon "status". Doe No. 11 kicked three others, and was kicked by No. 4; No. 6 kicked No. 2, and was kicked by No. 3. Group 3 or the basic group included the two fawns, two yearling does, and four does who were kicked at by most of the others or moved aside very promptly upon the approach of deer in Groups 1 and 2. These deer bedded down at the periphery of the herd.

There was relatively little mutual neck licking or mouthing carried on between individual deer. There were only 38 recorded exchanges between the

does, and only three cases of mutual neck grooming between the buck and some doe. This does not include the routine morning inspection of the females by the buck.

Grooming by magpies.—Magpies occasionally flew into the corral, making off with stock pellets and sometimes grooming the deer. On November 13, 1955, two magpies flew and hopped from bedded deer to bedded deer to standing deer. The birds pecked at the eyelids and along the nose and side of the face of a number of does; they seemed to be particularly and persistently interested in pecking with the cavities of the external ears and along the necks of the deer. The deer frequently turned its head to the magpie roosting on its back, allowing the bird a better vantage point to work on the eyelids, nose and side of the face. Occasionally, when a deer shook its head after a magpie had been particularly persistent within the ears or along the nose, the magpie fluttered off and frequently returned. Magpies also explored a number of backs and repeatedly pecked at some object (ectoparasite?) within the hair. Once a magpie "worked over" very thoroughly the edge of the toes, the feet and legs of the buck and a doe.

Sickness.—Some of the had suffered minor bruises while being handled in squeeze chutes or manually restrained during the initial marking and tagging process, but actually most of them had been only thoroughly alarmed. One doe developed "stiff hind quarters" by November 5, showed signs of paralysis, and died on November 11. Another doe was "off her feed" on October 30, became gradually thinner, exhibited evidence of diarrhea, and died on November 15. No autopsies were performed. A third doe continued to exhibit symptoms immediately after being marked and for several marks thereafter she improved. Initially she walked stiff-legged with a partly arched back, seemed to have "cramps," exhibited diarrhea, and bedded down very frequently. She was autopsied on December 29 and exhibited no internal injuries or lesions, and appeared normal except for loose colon contents. Transitory diarrhea was exhibited by three other deer, possibly due to the feeding of several bales of moldy hay.

Preliminary breeding habits.—The buck had a habit, apparent from the beginning of observations of frequently urinating on his own hind legs. He placed his hind legs close together and slightly forward, and urinated on the metatarsal gland region. In most instances he then proceeded to lick this particular area. Infrequently the licking was followed by transitory penile extrusion. Usually, after licking fresh doe's urine, he threw his neck forward, his head and antlers back, retracted the upper lip from the gum, and stood quietly for a quarter to half a minute, seemingly analyzing the sample.

Exploratory activities.—The buck had a daily behavior pattern which was established very soon after he was first isolated from the does. Upon his morning release into the does' corral, he smelled the ground extensively, apparently for urine samples. He then examined the external genitalia of every doe. Sometimes the buck went directly to the does for his morning inspection; at other times he limited himself to analysis of cast urine samples, but most frequently

he combined both patterns. During the early period of observations, he selected some doe and casually followed her for a very brief time. He unsuccessfully mounted two of the does so followed; they showed little or no interest in his activities.

"Running" of does.—The buck's behavior pattern became considerably more aggressive after the first doe came into heat and was bred on November 27. After his usual morning inspection, he frequently chased the does around the corral. His actions were usually as follows: he gave a high-pitched grunt which at once alerted all the does, extended and lowered his neck, extended his head forward so that the antlers were back along his neck, vigorously smacked his lips, and occasionally panted and approached the does more or less stiff-legged. The does invariably moved away quickly when he assumed this posture. The "running" behavior usually took place during the first two morning hours but sometimes occurred four or five times later in the day. Each chase lasted from four to five minutes or longer.

Mating behavior.—The buck appeared very excited the morning of November 27. He investigated all the does but none of them seemed receptive. After the buck drank and returned to the herd, one doe stood for him and he unsuccessfully tried to mount. He rubbed his antlers on her neck, licked her face, neck, and external genitals, and attempted again but did not mount. The doe threw her head from side to side, which seemed to provide the impetus he needed. He mounted and mated successfully, but a car pulled up at the slaughter house just then and caused the doe to "spook." She ran a few steps, stood still and humped her back. A 32 mm. embryo was recovered from her on January 14. Early on the morning of December 17 the buck successfully mated with another doe. A 6.6 mm. embryo was recovered from her on January 14.

In four observed matings, the buck bred three does within approximately an hour and a half after his release into the breeding pens and a fourth late in the afternoon just before being isolated.

Summary.—Most of the routine daily movements of the penned herd between 8 A.M. and 4 P.M. were between the feeding lane along the east fence and the bedding grounds near the south and southeast end of the corral. All the deer were observed drinking water, the majority early in the morning. Some animals drank several times a day. Feeding was confined largely to the early morning and late afternoon hours, although there was some feeding activity throughout the day. Weather influenced feeding behavior to a marked extent. Cud chewing was seen while the deer were bedded, and less frequently while standing. Most of the bedding took place from mid-morning until mid-afternoon. Individual deer had preferred bedding areas, but rarely returned to the precise spot to bed again. The herd tended to bed as a group, rather than with individuals scattered at random throughout the corral. Certain deer consistently tended to bed earlier than the herd as a whole. A study of the "kick order" showed a dominant group of three individuals.

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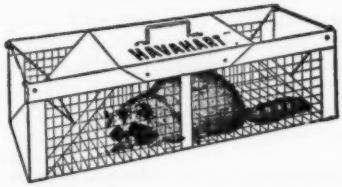

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OBSERVATIONS ON BODY TEMPERATURE IN A HEDGEHOG

Our knowledge of body temperature in most small mammals has until recently been quite limited. But because of the great interest in hibernation, there are a number of references to the body temperature of the European hedgehog, *Erinaceus europaeus*, including 8 reports prior to 1850 and a dozen since that date. Many of these represent only single values but more recently several quite substantial studies have been reported (Herter, 1934; Eisentraut, 1935; Suomalainen and Suvanto, 1953). But of these three, one represents subdermal values and another, measurements on immature animals. Because of its unique taxonomic and physiological position additional data is needed, particularly since it will allow us to directly compare this interesting animal to various North American species.

Methods.—These measurements were taken over a two-week period in March of 1952, shortly after the animal was sent from Norway by air through the kindness of Dr. Arnold Baaken. During the term of these measurements, it was kept at home and allowed the run of a room containing its nest box. Food was largely milk and eggs. Temperatures were taken rectally with short range (30–40° C.) mercurial thermometers which were read to 0.1° C. A standard insertion depth of 55 mm. was used. In five pairs of values taken at 55 and 25 mm., respectively, differences ranging from 0.7 to 1.3° and averaging 0.96° were observed.

Results.—The mean values of 45 measurements are summarized in Table 1. The values (35.5 – 36.2°) are lower than those of most mammals (Morrison and Ryser, 1952) but this does not represent a lack of thermoregulatory capacity since the low variability of the values (σ = 0.22 – 0.34°) is a striking feature. Only a small fraction of the values (6/33) represented the active animal since this species appears to be active only when hungry and feeding or searching for food. Conditions were inadequate for observing a natural 24-hour cycle, but the "dark" values (midnight to 6:00 A. M.) were significantly higher than the "light" values. A good correlation between temperature and activity was seen, although the difference (0.50°) was small. Induced or forced activity resulted in only slightly higher values than the natural activity with a limiting high temperature of 36.5 – 36.6°. This warming was a slow process, averaging only 0.057° /min. (0.4 – 0.8°/min.) in six experiments. Mean increases of more than 0.5° /min. have been observed in some species of small mammals (Morrison, Ryser and Dawe, 1953). It would appear that this mild and retiring animal is not capable of such vigorous activity.

The animal resisted moderate cold well, showing values of 35.4° and 34.8° after exposures

TABLE 1. — *Body temperature in Erinaceus europaeus at 17–21°C*[1]

CONDITION	MEAN	σ	NO.	RANGE	ΔT	t
Undisturbed	35.60	0.32	33	34.8–36.4		
Day (06°°–24°°)					0.40	3.6
Night (00°°–06°°)	35.90	0.34	8	35.4–36.4		
Quiet	35.53	0.24	27	34.8–35.7	0.50	5.0
Active	36.03	0.22	6	35.8–36.4		
Induced activity (15–30 min.)	36.23	0.23	12	35.9–36.6	0.20	1.9
All active	36.17	0.25	18	35.8–36.6		

[1] One "quiet" value of 34.2 was omitted from the average since it was 5 σ from the mean.

of 1.5 hrs. at 3° and 6 hrs. at 6° respectively. Both of these values were within the normal, quiet temperature range.

Comment.—Most observations of hedgehog temperatures have been characterized by their considerable variability, having been usually made during the hibernating season. But in the summer or when inactive animals were carefully excluded, Herter (1934) found a range of about 2°. The mean of our March values (35.6°) corresponds to Herter's summer value (June = 35.5°) rather than his winter mean (December–January = 34.6°). Our animal appears to have already made the transition to the active summer condition, possibly because of disturbance in transit. A similar 1° difference in summer and winter temperatures was reported by Chao and Yeh (1950) for a large series on a related species, the Chinese hedgehog, *E. dealbatus*, but their values were 0.4° lower (35.1 and 34.2°) than those of Herter.

Suomalainen and Suvanto (1953) found a temperature of 34.3° in non-hibernating *E. europaeus*, but this represented subdermal measurements (anteroventral) and not "deep" or "core" temperatures. Lower subdermal values down to 32.5° (postero-dorsal) were found in other areas. Recently, Eisentrant (1952) has reported measurements on the desert hedgehog, *Paraechinus aethiopicus*, which average 34.0° for breast skin value on two adults at about 20° C. Since both he and Chao and Yeh observed an average differential of 0.8° in simultaneous pairs of breast and rectal measurements, the value for this species appears quite in line with the winter values of Herter and of Chao and Yeh for European and Chinese hedgehogs. At lower ambient temperatures (7°), however, the desert hedgehog was about 1° cooler. Earlier, Eisentrant (1935) reported a body temperature of 35.2° in young hedgehogs of 13–31 days of age.

Although the insectivores are considered a primitive order and although we tend to associate a low body temperature with poor thermoregulation, this animal showed a more uniform body temperature ($\sigma = 0.32$, including effects of activity, diurnal cycle and ambient temperature) than do most small mammals.

Summary.—Fifty body temperature measurements were made on a non-hibernating hedgehog in March. The undisturbed animal averaged 35.60° with a σ of 0.32° and a range of 34.8 – 36.4°. The following differences were observed: day *vs.* night, 0.40°; quiet *vs.* active, 0.50°; 25 mm. *vs.* 55 mm. depth, 0.96°.

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PETER R. MORRISON, *Departments of Zoology and Physiology, University of Wisconsin, Madison.* *Received April 7, 1956.*

A SECOND DWARF SHREW FROM NEW MEXICO

On August 18, 1954, a dwarf shrew, *Sorex nanus*, was captured by the author near Capulin Ranger Station in the Sandia Mountains, in sec. 33, T. 12N, R. 5E, Sandoval County, New Mexico. This is approximately 70 miles southwest of the locality in the Sangre de Cristo Mountains where the first specimen from New Mexico was reported by Koster and Clothier (Jour. Mamm., 33:250–251, 1952).

The Sandia Mountain specimen, a male with unworn teeth, is preserved as a study skin and skull (No. 1384) in the mammal collection of Arizona State College, Tempe. Its measurements are: total length, 94; tail, 39; hind foot, 10; ear from notch, 5; condylobasal length, 14.8; palatal length, 6.2; cranial breadth, 7.0; least interorbital breadth, 3.0; maxillary breadth, 4.1; alveolar length of maxillary tooth row, 5.4 mm. The weight was 2.8 grams.

The dwarf shrew was captured in a Museum Special trap baited with peanut butter, set under a rotten log in a mixed aspen (*Populus tremuloides*) and white fir (*Abies concolor*) forest at an elevation of 9,000 feet. This locality is over one-half mile from the nearest known water which consists of an enclosed spring at Capulin Campground. Further attempts to obtain more shrews from this area were unsuccessful. Other mammals taken at the same locality were *Peromyscus maniculatus rufinus, Microtus longicaudus mordax, Thomomys bottae actuosus, Eutamias quadrivittatus quadrivittatus,* and *Neotoma mexicana fallax.*

A survey of the literature indicates that six dwarf shrews have been reported from four localities in central and western Colorado, two from western and southern Wyoming, one each from northern Arizona and southeastern Utah, and that the records from two localities in northern New Mexico make the total number of known specimens apparently 12. Merriam (North Amer. Fauna, 10:82, 1895) records an additional specimen, now apparently lost, from Fort Custer, Montana. The above records are from elevations between 7500 and 10,500 feet.—Ronald R. Clothier, *Arizona State College, Tempe, Arizona.* *Received May 7, 1956.*

PEAK POPULATIONS OF THE MASKED SHREW IN NORTHERN ONTARIO

It appears useful to record the presence of a widespread population peak of the masked shrew (*Sorex cinereus* Kerr) starting in the late summer of 1955, and possibly continuing into early 1956, for northern Ontario. I obtained the first evidence of high populations on a small mammal trapline on Little Missinaibi Lake, Chapleau Crown Game Preserve. Other data regarding the population status of the species were kindly provided by W. R. Eadie, C. D. Fowle, and B. S. Falls.

The following catch records were obtained for the Chapleau trapline, consisting of two parallel linear traplines 400 feet apart, each with twenty stations 50 feet apart, consisting of three traps set for three nights and three days (Table 1).

Table 1.—*Catch of small mammals in the Chapleau Game Preserve, 1955, 1956*

Trapping dates	*Sorex*	*Peromyscus*	*Blarina*
June 6–9, 1955*	0	1	0
July 8–11, 1955	5	1	1
Aug. 6–9, 1955	56	0	1
Nov., 1955**	4	0	0
Jan. 3–5, 1956**	3	0	0
Jan. 14–16, 1956**	2	0	0
March 7–8, 1956**	1	0	0

* inclusive

** trapping under the snow

The habitat in which the traplines were located was partly a mixture of mature jack pine and white spruce, and partly mature trembling aspen. It is interesting that no *Clethrionomys g. gapperi* were caught; these are normally the most common mammals in this general region (de Vos, Tech. Bull., Ontario Dept. Lands and Forests, Toronto, 1952). During the period 1948–1950, only 0.3 *Sorex cinereus* were caught per 100 trap-nights under similar habitat conditions, but during the summer months in the Chapleau region, the catch in 1955 was 5.7 per 100 trap-nights.

Evidence of the possibility of a high population of *Sorex cinereus* during the winter 1955–1956 was provided by trappers in the area where the Chapleau small mammal trapline was located. They trapped large numbers of these shrews in their cabins, but no other small mammals. The same trappers informed me that no small mammals were present in these cabins during the winter 1954–1955.

The two traplines were operated under the snow with the traps on the ground during the months of November, January and March (Table 1). Small numbers of shrews were trapped. However, trapping under winter conditions may not be comparable to summer trapping. The same traplines were again trapped during the period May 26–29, 1956. Neither *Sorex cinereus*, nor *Clethrionomys* were caught. Two other traplines operated in early June, 1956, in the same general locality, also failed to produce any shrews.

C. D. Fowle provided data on high catches of *Sorex cinereus* near Heron Bay in a mixed woods area on the northern slope of Lake Superior. Catches were made using two lines of 150 traps each, set in pairs of 75 stations spaced about 25 feet apart (Table 2). The catch of *Sorex cinereus* was higher in an uncut mixed forest area than in the freshly cut area.

TABLE 2.—*Catch of small mammals at Heron Bay, 1955*

TRAPPING DATES	*Sorex*	*Peromyscus*	*Blarina*	*Clethrionomys*	*Napaeozapus*
June 19–21	6	28	0	42	0
June 26–28	8	23	3	34	0
Aug. 25–27	46	46	0	143	1

The catch of *Sorex cinereus* in this area was 2.2 per 100 trapnights. It is interesting to note that in the previous year (1954), under similar trapping operations in June and September, only one shrew was caught.

W. R. Eadie trapped small mammals in late August near Lake Nipigon on a line of twenty stations, three traps each, from the forest edge into second-growth spruce balsam. Traps were operated for four days, including one night of heavy rain. His catch included the following: *Sorex cinereus*, 18; *Sorex arcticus*, 2; *Peromyscus*, 8; *Blarina* 2; *Clethrionomys*, 3; and *Microtus*, 5. This area produced a catch of 7.5 *Sorex cinereus* per 100 trapnights.

J. B. Falls provided information on masked shrew catches in Algonquin Park (Table 3). Sherman live-traps were set in lines of 10 traps each. Since this trapping method is different, results cannot be considered comparable.

TABLE 3.—*Catch of Sorex cinereus in Algonquin Park, 1955*

YEAR	*Sorex cinereus* PER 100 TRAP-NIGHTS	MONTHS IN 1955	*Sorex cinereus* PER 100 TRAP-NIGHTS
1952	0.3	May 26–28	0.0
1953	0.5	June 28–30	0.7
1954	0.6	July 28–30	0.7
1955	1.0	Aug. 29–31	4.6

In August, 1955, slightly more *Sorex cinereus* than *Clethrionomys* were captured. However, they did not approach the catch of *Peromyscus maniculatus gracilis*.

A comparison of the highest populations during August reveals the following:

Chapleau (de Vos)	15.5	per 100 snap-trap nights
Lake Nipigon (Eadie)	7.5	
Heron Bay (Fowle *et al.*)	5.1	

Algonquin Park (Falls & Standfield)—4.6 per 100 trap nights, using Sherman traps.

The data indicate that the peak population of *Sorex cinereus* during the late summer of 1955 was of a widespread nature in Northern Ontario.—ANTOON DE VOS, *Ontario Agricultural College, Guelph, Ontario. Received June 11, 1956.*

AN EXTRA TOOTH IN *CROCIDURA*

The occurrence of extra teeth in insectivores is apparently not common. Palmer (Jour. Mamm., 18: 280–314, 1937) states that approximately 10 per cent of the specimens of the mole *Scapanus*, examined by him, had abnormal dentitions, the tendency being toward a reduction but with some increase in the number of teeth. In every case the increase or decrease was in the premolar series.

Hall (Jour. Dent. Res., 19: 103–143, 1940) found no instance of supernumerary or missing teeth in 1,837 specimens of Soricidae examined. Jackson (N. Amer. Fauna 51, 1928) found only two examples of supernumerary teeth in *Sorex* and one in *Microsorex*, out of 10,431 specimens examined. These anomalies were in the unicuspid series.

It is interesting that, in examining specimens of the shrew *Crocidura* obtained by U. S. Naval Medical Research Unit No. 3 in Egypt, one specimen of *Crocidura olivieri*, Chicago

PLATE I

Palatal view of *Crocidura olivieri*, showing extra posterior molariform tooth. ×30.

Natural History Museum catalog number 74,939, a male from Abu Ghalib, Imbaba District, Giza Province, has a supernumerary molariform tooth.

This tooth lies at the posterior end of the upper left tooth-row (Plate I). It is triangular in shape with the apex of the triangle pointing anteriorly. Little relief can be noted on the occlusal surface but there is evidence the tooth has been above the gum line and worn. There is no trace of an extra tooth in the right maxillary or in either mandibular row.

This is apparently the first record of the appearance of an extra tooth at the posterior end of the toothrow in the soricids. Johnson (Jour. Mamm., 33: 70–72, 1952) suggests that a similarly placed supernumerary molar in rodents may actually be the third and that the classically accepted first molar may in reality be an unshed deciduous premolar. Perhaps this is a parallel case in insectivores.—HENRY W. SETZER, *U.S. National Museum, Washington 25, D.C.* *Received May 20, 1956.*

MYOTIS SODALIS IN FLORIDA

A single *Myotis sodalis* collected in Old Indian Cave about 3 miles north of Marianna, Jackson County, Florida, on October 14, 1955, apparently constitutes the first record of this bat in Florida and extends the known range of the species approximately 200 miles south of Anniston, Calhoun County, Alabama, the nearest locality from which it has previously been reported (Miller and Allen, U.S. Nat. Mus. Bul. 144, 1928). The specimen, which is in the collections of the University of Florida (No. 560), is an adult female with the following measurements: total length, 87; tail, 34; hind foot, 8; forearm, 38; ear from notch, 14; and ear from crown, 13 mm. It weighed 8.2 grams. A thick blanket of subcutaneous fat was present in the inguinal region and on the lower back, and a heavy deposit occurred between the scapulae. The right uterine horn was slightly more swollen than the left and contained sperm.

Old Indian Cave, one of several limestone caves in the Marianna region of west Florida inhabited by bats, is somewhat unusual among caves in this area in having three entrances. There is thus considerable circulation of air through the cave with the result that temperatures fluctuate rather markedly. The room in which the majority of bats are found is located approximately 200 feet from the main entrance and is reached through two passages and one large intervening room. It is large and irregular, with many crevices and short side passages. The floor is dry and covered with bat guano. A low crawlway leads from the room to a rear entrance of the cave some 30 feet away. The bats utilize both entrances.

It was estimated that about 800 *Myotis a. austroriparius* and 1200 *Myotis grisescens* occupied the main room on October 14. The two species were segregated in separate clusters on the walls and roof. About 20 *Pipistrellus subflavus* were dispersed throughout the cave, with a few hanging singly in the bat chamber. The *M. sodalis* was discovered in a sample of 200 bats, most of which had been collected after the bats were disturbed and the species had become mixed. The cave was visited again February 2, 3 and 22, 1956, but no additional *M. sodalis* were found, and the numbers of other species had declined.

Of the four species of *Myotis* now known from Florida, three (*M. grisescens, keenii* and *sodalis*) have been recorded only from the western part of the State in the vicinity of Marianna, the next nearest localities ranging from 200 to 290 miles farther north. A local population of *M. grisescens,* totaling over 4,000 individuals, has been reported by Rice (Jour. Mamm., 36:289, 1955) from Old Indian Cave and another nearby cave. In contrast, only single specimens of *Myotis keenii septentriornalis* (Rice, Jour. Mamm., 36:567, 1955) and *M. sodalis* have been taken in Old Indian Cave during October, even though numbers of bats have been examined from this and other caves in the vicinity on various dates in October, December, February and May. It is possible that these species occur in the state only as occasional migrants from farther north and not as apparently isolated local populations comparable to that of *M. grisescens.*—WILLIAM L. JENNINGS AND JAMES N. LAYNE, *Department of Biology, University of Florida, Gainesville, Florida.* *Received May 12, 1956.*

MYOTIS OCCULTUS AND *MYOTIS YUMANENSIS* BREEDING IN NEW MEXICO

There appears to be no record in the literature of the breeding of *Myotis occultus*. Cockrum (Trans. Kansas Acad. Sci., 58: 495, 1955) listed none, nor have I found any other reference. A pregnant female (R.E.M. No. 170) containing an 11-mm. (crown-rump length) embryo was taken by Raymond J. Fleetwood and myself on May 27, 1953. We took this bat, along with eight gravid *Myotis y. yumanensis*, from a building on the Bosque del Apache National Wildlife Refuge, near San Antonio, New Mexico. I had previously taken a male *occultus* (U.S. Nat. Mus. No. 297,235) at the same site on May 26, 1953.

Each of the eight *yumanensis* contained a single embryo; these measured 8, 11, 12, 12, 12, 14, 14, and 16 mm. respectively, in crown-rump length. Four were preserved as alcoholics and deposited in the U.S. National Museum (Nos. 297,237–297,240). An additional 33 *yumanensis*, all evidently gravid, were captured and released.

I wish to thank Dr. Charles O. Handley, Jr., for identifying the specimens and reporting on the breeding condition of the alcoholics.—Russell E. Mumford, *University of Michigan Museum of Zoology, Ann Arbor, Michigan.* *Received June 2, 1956.*

RECORDS OF THE SPOTTED BAT FROM CALIFORNIA AND ARIZONA

Specimens of the little-known spotted bat, *Euderma maculata* (J. A. Allen) are still so few in number that the following notes on two recently acquired specimens in the collections of the Los Angeles County Museum are considered worthy of record.

On January 24, 1956, Mr. Darwin Tieman of the Naval Ordnance Test Station at China Lake, California, discovered a mummified but well-preserved specimen of *Euderma maculata* near a pile of rocks at the edge of China Lake (dry), just inside San Bernardino County and approximately four miles south of the Inyo County line. Curious as to its identity, Mr. Tieman sent the specimen to me here at the Los Angeles County Museum. The specimen (LACM 9822) is an adult male with a radius of 48.0 mm. and a tibia of 22.0 mm.

The other specimen (LACM 9823) is also an adult male and was collected at Tempe, Maricopa County, Arizona. The history of this specimen is a bit obscure, as it changed hands a number of times prior to the Los Angeles County Museum obtaining it on October 20, 1953. According to Mr. Mike Kallal, who presented it to the museum on the above date, the bat was killed by a small boy in Tempe, Arizona and brought to the Scorpion Research Laboratory in that city. Personnel at the Tempe laboratory did not recognize the specimen as being the rare spotted bat, but because of its curious markings injected it with formaldehyde (?) and dried it with wings spread and ears extended. A school teacher at Covina High School, where Mr. Kallal is a Biology student, obtained the specimen from the personnel at the Scorpion Laboratory and brought it to Covina, California, in October, 1953. Mr. Kallal immediately recognized the bat as *Euderma maculata*, obtained it from his teacher and presented it to the Los Angeles County Museum. The specimen is well preserved, but with the skull still *in situ*. The radius measures 49.0 mm. and the tibia 22.0 mm.

These two specimens are the thirteenth and fourteenth of this species known to me to be preserved in study collections. The records are the seventh for California and the second for Arizona.—Kenneth E. Stager, *Los Angeles County Museum, Exposition Park, Los Angeles 7, California.* *Received March 12, 1956.*

ARCHAEOZOOLOGICAL EVIDENCE OF THE SPOTTED SKUNK IN ILLINOIS

East of the Mississippi River, the spotted skunk (*Spilogale*) is known to occur in Georgia, South Carolina, all of the Gulf Coast states, and northward in the Appalachians to south-central Pennsylvania. No spotted skunks have been collected north of the Ohio River, but on the basis of hearsay Howell (Proc. Biol. Soc. Wash., 23:23-24, 1910) reported them in southern Illinois from Golconda and in southern Indiana from New Harmony, and Hahn (33d Ann. Rept., Dept. Geol. and Nat. Res. of Indiana, 1909) reported them from Knox County, Indiana. In western Illinois, spotted skunks have been reported from the vicinity of Pere Marquette State Park, but to our knowledge this again is based not upon an actual sight record but rather upon hearsay. Thus, to date, there is no authentic record of the spotted skunk for Illinois. Its presence, however, in the western part of the state, anywhere along or near the Mississippi River, might be expected since the species is fairly common in eastern Iowa and parts of eastern Missouri. Nevertheless, search in this part of Illinois has not revealed its presence.

During the summers of 1953 and 1955, the Illinois State Museum's archaeological field parties excavated portions of an Indian rock shelter camp site located approximately two miles northwest of Modoc, Randolph County, Illinois. The site is situated at the base of the old Mississippi River bluff and was occupied primarily by peoples of an archaic culture. The period of occupancy has been dated (carbon 14) from approximately 9,000 B.C. to 1,000 B.C. Parts of one maxillary and seven dentaries of the spotted skunk, *Spilogale*, were found among the varied and large amounts of bone and shell recovered at the Modoc site. These were all found at levels that fall in a time period of approximately 4,500 to 2,500 B.C. It is impossible to be sure if the spotted skunks represented by these remains came from the immediate vicinity of the Modoc site, but judging from other remains, one would be inclined to think so. If such is the case, these jaws provide evidence that the spotted skunk, at least formerly, occurred in Illinois. More than one species of mammal collected at this site is known to have had a range different from that of today. For example, pocket gophers, *Geomys bursarius*, are present in the remains near Modoc, yet this is 35 miles south of the present-day range of this species.

On a geographical basis and the size of the upper molar, these specimens would seem more nearly referable to the form *S. interrupta* (Rafinesque).—PAUL W. PARMALEE AND DONALD F. HOFFMEISTER, *Illinois State Museum, Springfield, and Museum of Natural History, University of Illinois, Urbana.* *Received May 23, 1956.*

BLOOD VALUES OF TWO AMERICAN CARNIVORES

In the course of an investigation of the blood coagulation mechanism of a series of mammals, a male raccoon (*Procyon lotor*) and a female bear (*Euarctos americanus*) were

TABLE 1. — *Blood values of the American black bear*

TEST	VALUE
Leukocyte count	5,650mm³
Differential: Neutrophils	72%
Lymphocytes	17%
Eosinophils	1%
Hematocrit	38.0%
Specific gravity of whole blood	1.050
Specific gravity of plasma	1.021
Platelets	465,000mm³
Whole blood clotting time (1 ml.)	5.0 min.
One-stage prothrombin time (rabbit lung thromboplastin)	7.8 sec.
Two-stage prothrombin concentration (bovine fibrinogen)	233 units

presented to the author. The raccoon was captured twenty-four hours before studies were made, near Littlestown, Pennsylvania. The bear, a yearling weighing 21 kg., was captured approximately a week before the studies were made, in the Adirondack region of New York. Twenty-four mls. of blood were taken from the femoral vein of the bear under sodium pentobarbital anesthesia. The raccoon was exsanguinated by intracardiac puncture, after anesthetization with sodium pentobarbital.

The data from the blood studies conducted on these two mammals are presented in Tables 1 and 2. The leukocyte and differential counts were made by the usual method. The whole blood clotting was done by the technique of Lee and White (Am. Jour. Med., 145:495, 1913), the hematocrit by Wintrobe's method (CLIN. HEMAT., Lee and Febiger, Phila., 1951), the platelet count by Brecher and Cronkite's method (HEMORRHAGIC DISEASES, C. C. Thomas, Springfield, Ill., 1942), the prothrombin concentration by Ware and Seeger's method (Am. Jour. Clin. Path., 19:471, 1949), and the specific gravity by the "copper sulfate" method. The serum prothrombin conversion accelerator determination was done by the method of de Vries *et al.* (Blood, 4:247., 1949).

TABLE 2. – *Blood values of the raccoon*

TEST		VALUE
Leukocyte count		7,025mm³
Differential:	Neutrophils	67%
	Lymphocytes	29%
	Monocytes	3%
	Basophils	1%
Hematocrit		34.5%
Whole blood clotting time		8.1 min.
One-stage prothrombin time (homologous lung thromboplastin)		10.2 sec.
One-stage prothrombin time (10 different heterologous lung thromboplastins) range =		10.2 to 49.9 sec.
Two-stage prothrombin concentration (homologous fibrinogen)		134 units
Two-stage prothrombin concentration (8 different heterologous fibrinogens) range =		34 to 318 units
Serum prothrombin conversion accelerator (homologous reagents)		89%

The blood values presented in Tables 1 and 2 do not deviate greatly from normal ranges determined by other investigators. In a more complete study on eleven mammals, the author (Diss., G. Washington U., 1955), found that results of many coagulation tests are dependent upon the specific reagent used. Hence, it is not surprising to find that the prothrombin level of the raccoon may range from 34 to 318 units according to the fibrinogen used. In the case of the bear, Svihla *et al.* (Jour. Mammal., 36:314, 1955), working with the American black bear, found a much higher leukocyte count, higher neutrophile count, lower lymphocyte count, lower hematocrit value and longer whole blood clotting time. However, these workers may not have been using the same species, and moreover were using a captive animal, whereas the bear used in this study came from the wild state.–G. J. JACOBS, *National Research Council, Washington, D.C. Received April 18, 1956.*

OBSERVATIONS ON BEHAVIOR OF THE COATIMUNDI

Observations on inherited behavior patterns of mammals and the manner in which they enable a species to live as it does or where it does have for the most part been neglected by mammalogists. A knowledge of inherited behavior and its capability of being modified under different environments may have important implications not only in the control or management of certain species but also in understanding their ecology, distribution, and evolution. During the past six years I have had opportunity to make certain field observations on wild coatimundis (*Nasua narica*) in Veracruz, Chiapas, Yucatán, and Panamá. Two of these seem worth recording, especially when compared with the behavior of a captive which was taken, while still very young, from its wild mother in southern Yucatán. This young female (*Nasua narica yucatanica*) was captured in the forest near Chocholá, Yucatán, early in July, apparently only a few days after its eyes had opened. Since that time it has been kept in Fresno, California, and has never seen or been near another coatimundi. Any peculiar behavior traits that it possesses that have also been observed in wild coatimundis are therefore presumed to have been inherited.

Arboreal behavior.—Although troops of coatimundis have at times been surprised while rooting and digging in the soft soil or forest litter, they have also been observed many times as high as 100 feet above the ground feeding on wild figs or star apples, or cutting loose the large fruits of introduced breadfruit trees. These animals have little difficulty in climbing even the largest trees in the tropical forests, or in going from tree to tree along the horizontal interlacing branches or even running, sloth-like, on the underside of the great lianas. When a coatimundi descends it does so by coming down head first with its hind feet turned around after the manner of a descending tree squirrel. The tail also plays an important part in its arboreal activity. As it walks on small horizontal limbs, it swings from side to side as an aid in balance. In descending a liana or branch at a steep angle the tail is almost prehensile, but not to such an extent as in the kinkajou (*Potos flavus*). In making a nearly vertical descent, the long, tapering tail is curved around the vine or branch and pressed tightly against it. In this manner the tail of the coatimundi acts as a brake and allows the animal to descend quickly, even vertically, small trees and vines, *but not the smooth trunks of large trees.* Large trees are normally descended by running out toward ends of the drooping branches and transferring to the nearby branches of the same tree, or another at a lower level, and rarely by coming straight down the vertical trunk where the braking effect of the tail is greatly reduced.

The captive coatimundi has been observed also to make rapid descents from large cottonwoods and oaks in California by going to the ends of the branches and dropping to lower ones, or by going to an adjacent tree. However, on several occasions when it has climbed large Jeffrey pines and red firs, the descent has posed a serious problem for the animal and it has required a half hour or more to come down from the height of 80 feet or less. Because of the spaces among the trees the animal could not go to a lower level by running to the end of the branch and transferring to another tree, and hence it was required to descend from limb to limb along the vertical bole, which it did with the greatest of care by keeping its tail over the upper limb as long as possible, slowly creeping down to the next lower limb. As each lower limb was reached, it was immediately explored to its very extremity for possibilities of getting to other trees or for getting onto still lower limbs on the same tree, but within safe jumping distance. Sometimes each of these limbs was explored several times before the animal would risk itself going down a few more feet on the large vertical trunk which was either very smooth or covered with treacherous, scaly bark that might not support its weight. The animal will descend the vertical trunks of large trees, where its *tail cannot be used* as an effective brake, *only* if there is no other recourse. Thus a pattern of inherited behavior that serves the coatimundi very well in going through or up or down in its own native forests frequently gets it into difficult situations and does not provide it with the same freedom of movement in the foreign Sierran coniferous forest.

PLATE I

A coatimundi, *Nasua narica yucatanica*, rolling a tarantula preparatory to eating it.

Feeding behavior.—The coatimundi is a general feeder and for its animal food it prefers arthropods to vertebrates. Certain species of arthropods can inflict painful bites and stings which give them considerable immunity from persecution by most vertebrate predators. The coatimundi is admirably equipped with an interesting inherited behavior pattern that enables it to utilize this rich source of energy represented by stinging ants, wasps, hornets, caterpillars, scorpions, and tarantulas.

When the coatimundi encounters one of these invertebrates it begins to roll it on the ground very rapidly under the thick paws of the forefeet with the two front legs alternating in rapid motion. Soon the legs, wings, "poison hairs," and scales are rubbed off, and then the food is ready for chewing. Even large harmless moths and butterflies and slimy slugs and snails are prepared in this manner.

When the young Yucatán coatimundi was about 6 months old she was given three tarantulas that had been captured alive in the foothills near Fresno, for the purpose of testing this behavior pattern that had been observed so many times among the wild coatis. Although it is certain this young animal could never have seen this action in any other of her kind, she pounced on the tarantulas unhesitatingly, and after rolling them thoroughly, soon had them as well-prepared for eating as though she had been doing it all her life. It seems likely that this was the first time this instinct was ever used by this captive animal, but it was nevertheless very effective in its results.

This bit of behavior serves the coatimundi as well, perhaps, away from its native forests as it does at home. It seems likely that most of the coatimundi's behavior traits would function for its well-being in a foreign environment, but it is certainly conceivable that *just one* inherited behavior pattern might be its undoing if it could not be adjusted to a new environment, and thereby might limit its distribution geographically or ecologically. The study of inherited behavior in mammals is a fertile field for investigation, especially when closely related species are tested for their differences.—Lloyd G. Ingles, *Fresno State College, Fresno, California.* *Received June 5, 1956.*

NOTES ON A SPECIMEN OF THE HARBOR PORPOISE

On May 20, 1955, a small whale was washed ashore at Stillwater Cove, Pebble Beach, Monterey County, California (36°34'N, 121°56'W). Thomas N. Fast, Dr. Elliot C. Williams, and Eric Barham from the Hopkins Marine Station of Stanford University secured the animal while it was still alive and brought it back to the laboratory where it was identified as a harbor porpoise, *Phocoena vomerina* (Gill) (Plate I). The porpoise was placed in a large concrete tank filled with sea water. Externally the animal revealed no cuts, lacerations, or abrasions, but it died at the end of twelve hours.

This peculiar species of dolphin is the smallest cetacean inhabiting the North American Pacific Coast. Since it has rarely been obtained in satisfactory condition, measurements and notes on the specimen were recorded. The porpoise was deep-frozen and shipped to Dr. Raymond Gilmore of the U.S. Fish and Wildlife Service at the Scripps Institution of Oceanography. He has kindly verified the identification, and added that the specimen was an old male.

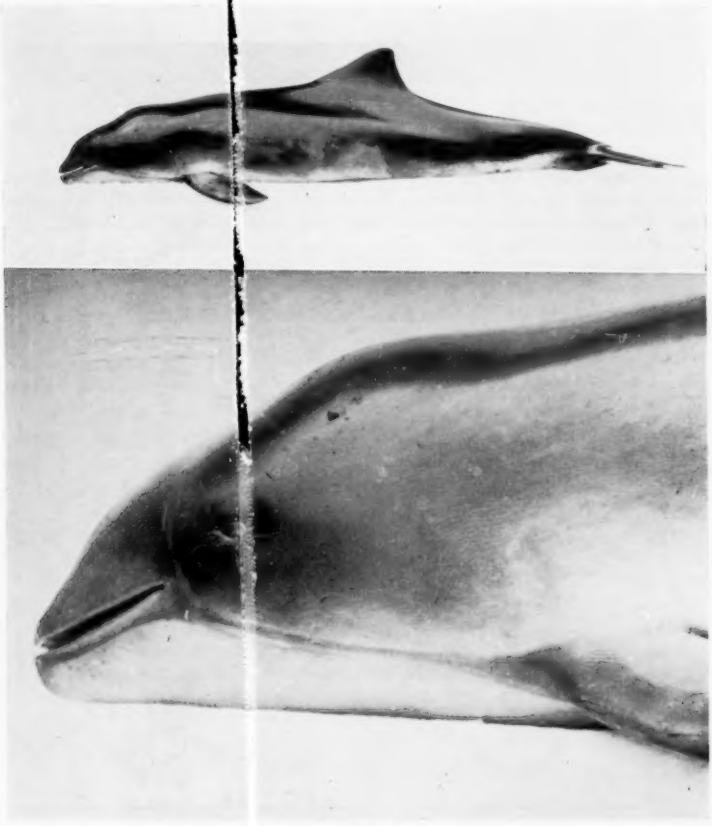

PLATE I

TOP: Lateral view of *Phocoena vomerina* (Gill).

BOTTOM: View showing extension of black streak from angle of jaw to origin of flipper.

Measurements (in cm.) of the specimen were as follows: from tip of snout to notch of flukes, 129.5; from tip of snout to corner of mouth, 10.5; from tip of snout to eye, 13.0; from tip of snout to spout-hole, 13.0; from tip of snout to insertion of flippers, 26.5; from notch of flukes to tip of fin, 4.5; from notch of flukes to vent, 40.5; from notch of flukes to genital slit, 65.0; length of beak, 3.2; breadth of flukes, 31.0; height of fin, 10.0; base of fin, 22.0; length of flippers, 23.0; maximum width of flippers, 23.0; girth, 69.0; weight, 60 lbs.

The color was slate black on dorsal and dorsolateral surfaces, with mottled gray and white on ventral surface. There was a whitish streak on the peduncle, and a definite streak extending posteriorly from angle of jaw to the origin of the flipper (Plate 1).

The teeth were spade-shaped, 20 on each side of the lower jaw, with gingival tissue rising to a height almost equal to that of the lower teeth. No teeth were apparent in the upper jaw; however, a hard "dental" ridge was present.

The shape of the head gives little impression of a beak. The skull is depressed above and around the spout-hole.—RICHARD A. BOOLOOTIAN, *Hopkins Marine Station, Pacific Grove, California.* *Received May 27, 1956.*

FLUCTUATIONS IN POCKET GOPHER POPULATIONS

Little information is to be found in the literature on periodic fluctuations or cycles in pocket gopher populations. Kalmbach, in January, 1950, prepared a typewritten report on the results of the Grand Mesa pocket gopher study in Colorado, in which he stated in part: "The high of 1945 and that of 1949 with the intervening lows would indicate that there may be some periodic fluctuation in the gopher population on the Mesa since the man-days of trapping in the several years were not greatly different."

A joint study between the Forest Service and the Fish and Wildlife Service was undertaken in 1942 on the Manti-LaSal Forest in central Utah to determine what effects pocket gophers have on the vegetation found on the high summer range. As a part of the study, a fenced 4-acre plot was selected, one half of which was to be trapped yearly to keep it as free of gophers as possible, while on the other half the gophers were not to be molested.

Another area selected was a 5-acre tract which was trapped for gopher removal. The 5-acre tract was trapped uniformly from 1943 through 1949. This tract was discontinued after the September trapping in 1950, because half of the area was plowed and seeded to experimental grass plots. The 2-acre tract inside the fenced exclosure was trapped regularly from 1943 through 1955.

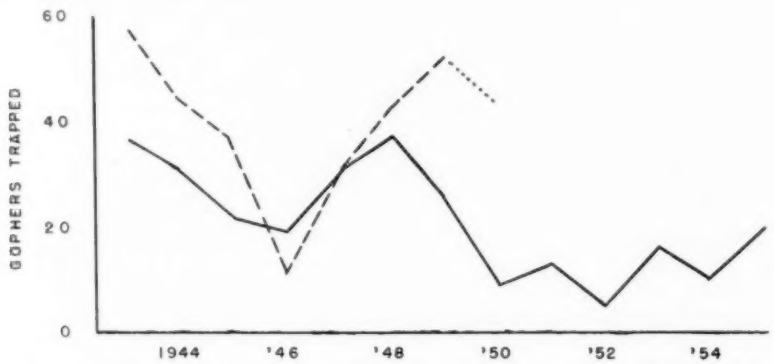

FIG. 1.—Numbers of gophers trapped on two areas in Utah, by years. Solid line, 2-acre tract; broken line, 5-acre tract.

The procedure followed was to trap the areas intensively as long as any surface activity by the gophers was evident. The gophers trapped after 1942, on the plots used in this study, were largely migrants or invaders from adjacent areas.

To determine the possible existence of cycles in gopher populations in Utah, all of the yearly trapping records except those obtained in 1942 were compiled and the yearly populations were plotted in graph form. Figure 1 shows the population changes that occurred by years. The populations on both tracts were at or near the peak in 1943. The second population peak on the 2-acre tract was reached in 1948, and on the 5-acre tract in 1949. It is possible that the second peak on the 2-acre tract would have occurred in 1949 also, had not a barrier fence been erected along its southern boundary late in 1948; this no doubt kept some gophers from invading the area. The population started downward on both tracts after the 1949 season. This is shown graphically for the 2-acre tract where there was a low in 1952, after which the population increased with minor fluctuations through 1955. The total catch for the entire 5 acres in July and for half the area in September was well below the 1949 take, showing that the population had started its decline after 1949. The graph shows a close parallel between the high and the low periods on the two Utah tracts. These do not correspond with the high and low periods in pocket gopher populations in Colorado except in the case of the high in 1949. The results obtained from the Colorado and the Utah studies show that pocket gophers, like many other wildlife species, are subject to periodic fluctuations in their populations through the years.—CLARENCE M. ALDOUS, *444 Federal Building, Salt Lake City, Utah. Received May 15, 1956.*

THOMOMYS BOTTAE AUREIVENTRIS HALL FROM NEVADA

When Hall prepared his work on THE MAMMALS OF NEVADA (Univ. Calif. Press, Berkeley, 1946) he had no pocket gophers of the species *Thomomys bottae* from northeastern Nevada. Durrant (Pocket Gophers of Utah, Publ. Univ. Kansas Mus. Nat. Hist., 6:182, 1952) reported specimens of *Thomomys bottae aureiventris* from the Utah-Nevada Boundary, on the east side of the Tecoma Mountains in Boxelder County, Utah, and from as far south as the Deep Creek Mountains in Tooele and Juab counties, Utah.

On July 15, 1954, the writer, in company with John Bushman and Richard D. Porter, while investigating the ecological relationships within the Great Salt Lake Desert obtained seven pocket gophers (3 adult, 4 immature) from alfalfa fields at Pilot Ranch. This ranch is located 15 miles south of Montello and 4 miles west of Pilot Peak, Elko County, Nevada. Critical study of the aforementioned specimens proves them to be referable to the subspecies *T. b. aureiventris*. These specimens do not extend the known range of this subspecies appreciably, but prove conclusively that pocket gophers of this species do occur in northeastern Nevada.

At present, specimens from Nevada are available only from Pilot Ranch, but additional collecting in the southern portion of the Deep Creek Mountains and in the adjacent areas to the west may disclose that members of this subspecies occur also in this area of Nevada. Three of the specimens, herein reported, are now in the collection of the Museum of Vertebrate Zoology, University of Utah, and four are in the study collection of Ecological Research, Dugway, Utah. Acknowledgment is made to Professor Stephen D. Durrant, University of Utah, for assistance in the taxonomic assignment of the specimens and for supervision of the material herein presented.—NORMAN V. CHAMBERLAIN, *Division of Biology, University of Utah, Salt Lake City, Utah. Received May 10, 1956.*

SIZES OF BEAVER CHIPS CUT FROM ASPEN

While studying the sizes of wood cuttings handled by beavers (Amer. Midl. Nat. 52: 510–512) at Allegheny State Park in southwestern New York, interest was aroused in the wide range of sizes of the wood chips and especially the measurements of the larger ones cut by the beavers. They are made in felling the trees from which the beavers obtain bark and leaves for food, and by dismembering the fallen trees, the beavers obtain the pieces of wood used as building material for construction of their dams and lodges.

There are two main types of chips, those which are composed mainly of the bark which is removed first, and since it is easier to cut, these chips are often much longer than the wood chips. The second type is composed entirely or almost entirely of wood, and of these the first and outermost pieces are usually the larger and longer ones.

While the beavers were harvesting and storing their food for winter, they were felling many large aspens (*Populus tremuloides* and *P. grandidentata*). The chips for this study were all picked up around the bases of the stumps of the felled trees, where the beavers had dropped each chip as it was cut from the bole of the tree. These pieces varied in length from small bits almost like sawdust to some that were several inches long. Their thickness also varied from thin fragments and splinters, the thickness of a wood toothpick, to pieces up to eight or more sixteenths of an inch thick. A quantity of the larger freshly cut chips of aspen wood and bark were collected for study and for measurement of the length, breadth, and thickness of each chip.

Since the main interest was the size distribution of the larger wood chips, all of those measured were at least 2 inches long, and each one used was sufficiently regular in shape to give reliable measurements for the three dimensions. They were taken just as they came in the pile. All measurements were made in inches and sixteenths of an inch.

The lengths of the 1000 aspen wood chips measured varied from 2 inches (the lower limit chosen) to 6 2/16 inches, the longest wood chip found. Of these 1000 chips, the majority (52.6%) were concentrated in three groups between 2 8/16 and 3 inches inclusive, while 74.8% were distributed in the five groups between 2 4/16 and 3 4/16 inches inclusive. The average length of the 1000 chips measured was 3.016 inches.

In thickness, the chips ranged from 2/16 to 9/16 of an inch; the average of those measured was 4.623 sixteenths inches. Of these larger chips measured, 81.1 per cent were 4/16 or more inches in thickness.

The widths of the chips ranged from 8/16 to and including 28/16 inches. Eighty-three and one-tenth per cent of these measurements were an inch or more in width.

The thick corky base bark of the trees tended to be cut away in wider and longer pieces than the woody growth. Where the bark is soft and green it is usually eaten, but the dead corky material of the trees that were being harvested was not good for food, so it was discarded like the wood chips. These bark strips were much less numerous than those of wood, numbering only 110 pieces as compared to 1000 of the wood chips. The maximum measurements were: wood chips, length 6 2/16, width 28/16, and thickness 9/16; bark chips, length 8 11/16, width 33/16, and thickness 8/16 inches.—ALBERT R. SHADLE, *Biology Department, University of Buffalo, Buffalo 14, N. Y.* *Received March 3, 1956.*

RECORD BEAVER LITTER FOR COLORADO

In April, 1956, a 69-pound female beaver was trapped by the writer in a slough along the South Platte River, 2 miles east of Masters, Weld County, Colorado. The animal contained eight well-developed fetuses, estimated to be within 15 days of term. The average length and weight were 8.3 inches and 8.6 ounces, respectively. Examination of the ovaries disclosed nine corpora lutea, indicating that nine ova had been produced. One, however, had failed to develop. Of the eight fetuses, five were contained in one horn of the uterus and three in the other. Sex, determined through careful dissection by Dr. Paul H. Baldwin, Colorado A. & M. College, was seven females and one male.

The principal foods of beavers in this locality are cottonwood (*Populus deltoides*) and willows (*Salix* spp.). Herbaceous foods, mostly sedges, known to be used in summer, are abundant. Farm crops are generally unavailable to beavers along this stretch of the South Platte. The elevation is 4,325 feet above mean sea level. This instance, although not a record in litter size for the beaver, represents the largest number of embryos officially recorded to date in Colorado.—KEITH G. HAY, *Colorado Game and Fish Department, Fort Morgan, Colorado. Received May 10, 1956.*

OBSERVATIONS ON BEAVER MOVEMENTS IN ALASKA

One hundred twenty-two returns have been received from beaver tagged in Alaska. The returns are from subsequent live-trapping and trapping by licensed trappers. Only one beaver has been noted to move over six miles. Beaver No. 796-797 was tagged as a two-year-old male on the Chatanika River near Fairbanks, Alaska, on September 15, 1952. This beaver was not retaken during the following trapping season nor during live-trapping the next summer. The Northern Commercial Company at Nenana bought the beaver's pelt with the tags attached during February of the 1954 trapping season. An investigation revealed that the beaver had been taken in the Nenana River about one mile from its confluence with the Tanana River.

Assuming that the beaver went in the most logical route, down the Chatanika River into and down the Tolovana River to its confluence with the Tanana River, then up the Tanana to the mouth of the Nenana River, it traveled at least 150 miles and probably in excess of 200 miles. About 55 miles of this distance were up the braided Tanana River against about a ten-knot current.

Eighteen of the remaining 121 beaver moved one mile or more, and only two of these moved as far as six miles; 16 moved less than one mile and 87 were recaptured in the same pond or general area in which they were tagged.—WILBUR L. LIBBY, *Alaska Cooperative Wildlife Research Unit, University of Alaska, College, Alaska. Received May 12, 1956.*

ONYCHOMYS LEUCOGASTER IN KITTSON COUNTY, MINNESOTA

Gunderson and Beer (Univ. Minn. Mus. Nat. Hist. Occas. Paper 6, 1953) listed the five known specimens of *Onychomys leucogaster* from Minnesota. Those, plus a sixth specimen from Lincoln County not previously reported, were all taken in the two western tiers of counties in Minnesota, the northernmost specimen being from Parkers Prairie in southeastern Ottertail County.

On October 9, 1955, Morris T. Anderson caught a grasshopper mouse in a trap set for pocket gophers in a potato field four miles west of Karlstad, Kittson County. Anderson reported that the soil in the field was sandy and that there were bushes and woods in the vicinity (*in litt.*). He recognized the mouse as being unusual and presented it to Tester. The specimen was slipping belly hair and was deviscerated immediately. Dickerman prepared it several days later. It was a male, measuring: total length, 159; tail, 43; hindfoot, 22.5; and ear from notch, 15 mm. The record extends the range 155 miles northward in Minnesota, and may be the northernmost record for the species on the east side of the Red River of the North. The specimen is in the research collection of the University of Minnesota Museum of Natural History.—ROBERT W. DICKERMAN, *University of Minnesota Museum of Natural History, Minneapolis, Minnesota,* and JOHN TESTER, *Minnesota Department of Conservation, St. Paul, Minnesota. Received May 12, 1956.*

FACTORS INFLUENCING THE DECLINE IN COMMENSAL RAT INFESTATIONS IN A RURAL AREA OF SOUTHWESTERN GEORGIA

Murine typhus investigations conducted at the Newton Field Station, Technology Branch, Communicable Disease Center, are concerned primarily with the ecological aspects of typhus eradication in rural areas. The feasibility of eradicating this disease from rural areas in which it is endemic has been demonstrated in preliminary studies by Mohr and Smith (manuscript).

The typhus eradication measures consisted chiefly of rat eradication by means of the anti-coagulant poisons in food and water baits, and anti-rat sanitation measures coupled with the application of DDT dust for control of rat fleas.

Since the possible eradication of murine typhus from a particular area involves the eradication or near eradication of rat colonies at rural premises, it is important to know the prevalence of rat infestations of these premises. If the prevalence were exceptionally low, eradication measures could be carried out more quickly and economically, and chances for successful elimination of typhus would be greatly increased.

It is the purpose of this note to show that in some areas the prevalence of rat infestations on such premises has declined greatly since 1946, and to indicate some of the factors probably responsible for this decline.

Methods and results.—As part of the studies conducted at the Newton Field Station, periodic investigations are made in untreated check areas in an effort to determine natural variations in the abundance and distribution of commercial rats, their ectoparasites, and the per cent of specimens with demonstrable typhus antibodies.

The records used for the determination of the prevalence of rat infestation of rural premises in 1946 were those collected by Hill and Morlan (1948) in Thomas County, Georgia, during their studies on the effects of the applications of DDT dust for the control of the ectoparasites of commensal rats. These data were secured chiefly during May, June, July, August, and October by inspectors who visited the premises and determined the presence or absence of rat infestation by actual inspection, by questioning the occupants, or by both methods. The prevalence of rat infestations in 1955 was determined by actual inspections of, and in many cases by trapping, the same premises from which the 1946 records were available. This work was carried out during the months of June, July, August, September and October 1955.

Reliable records from a total of 98 premises in rural areas of Thomas County were available for 1946, and 95 of these premises were reinspected for rat infestations in 1955 as shown in Table 1. The premises inspected represent random samples of the total within the area. It is to be noted that almost all (93.9 per cent) of the premises inspected in 1946 had rat infestations, while only slightly more than one-third (34.7 per cent) had rat infestations in 1955. It is indicated that the prevalence rate had declined almost 60 per cent during the nine-year period considered.

Discussion.—Several factors may be involved in the decline in prevalence of rat infestations in Thomas County since 1946. One of these which may be eliminated initially is essential change in rat-proofing construction measures at the rural premises. Inspection of

TABLE 1. — *Prevalence of infestation of rural premises by commensal rats in 1946 and 1955, Thomas County, Georgia*

YEAR	NUMBER PREMISES INSPECTED	NUMBER PREMISES INFESTED	PER CENT PREMISES INFESTED
1946	98	92	93.9
1955	95	33	34.7

the premises indicates that few, if any, measures are used to prevent rat harborage and damage in corn and peanut hay. These two crops furnish food for the majority of the commensal rats of farms and create the chief storage problems on small farms in the area. Drought conditions which have existed since 1949 constitute the most impressive factor which may have influenced infestation rates. Statistics from the U.S. Department of Agriculture (1945-1955) indicate that in Thomas County the average production of corn and peanut hay for the six-year drought period had been considerably below that for the preceding six-year period of normal rainfall. Food scarcity therefore is believed to have been one of the chief factors involved in the decline. Another factor which undoubtedly had some influence is the use of the anti-coagulant poisons in rat food and water baits by the individual farmers. In general, not enough bait is supplied and baiting is discontinued too soon to eliminate all the rats, but in some cases elimination of the rats has been accomplished either by the farmers or by commercial pest control operators. A fourth factor which appears to have contributed to the decline of rat infestations is the tendency of Norway rats to take over the territories formerly occupied by roof rats as observed by Ecke (1954). It is generally conceded that it is easier to eradicate Norway rats than roof rats with the more common food bait materials such as corn meal, or a combination of corn meal and rolled oats incorporated with anti-coagulant type poisons. Mechanization in farming has undoubtedly accounted for the elimination of some livestock food storage buildings, and certain cultural practices such as use of combines for harvesting peanuts, and use of Bermuda hay rather than peanut hay, have also deprived rat colonies of food and harborage.

If the deficient rainfall of the past six years has been the primary factor responsible for the rat decline, as appears probable, it is reasonable to assume that the return of a period of normal precipitation would be accompanied by an increase in rat colonies, rat emigration, and in the number of farms with rats. Such increases would reasonably be followed by an increase in the incidence of murine typhus fever both in rats and in humans if typhus was still present in the rats of the region. Approximately 12 per cent (6 of 52 tested) of the rats trapped in Thomas County in 1955 had typhus-positive antibodies in significant titers.

Summary.—Murine typhus fever is reservoired chiefly in the commensal rats of farms in parts of the southern and southeastern United States. The economic feasibility of the eradication of murine typhus is determined largely by the actual numbers of farms infested with commensal rats. Recent inspection and trapping of 95 premises previously inspected for rat infestation in 1946 indicated that only about one-third of these premises are now rat-infested, while over nine-tenths had rat infestations in 1946. It is postulated that the series of six drought years (1949-1955) was one of the chief factors to which the decline in rat infestations of farms may be attributed. The return of a series of years of normal precipitation would likely result in a rise in the prevalence rate of rat infestations, and presumably in murine typhus in both rats and humans.

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William W. Smith, *Communicable Disease Center, Public Health Service, Newton, Georgia.* *Received June 11, 1956.*

INDUCEMENT OF TORPIDITY IN THE WOODLAND JUMPING MOUSE

During a live-trapping study in a woodland in central New York in June, 1955, a number of woodland jumping mice (*Napaeozapus insignis*) were caught. Of 21 captures of these mice over a five-day period, mice were torpid on nine occasions and active on twelve occasions. The minimum daily temperatures recorded for these five days at the weather station on the Cornell University campus ranged from 48° to 57° F. The area trapped was about 500 feet higher in elevation than the Cornell campus and temperatures were probably somewhat lower. In addition, three of the days were rainy, and on these days a greater percentage of mice were found torpid.

The torpid mice were usually in the typical position previously noted by past observers. The snout was tucked between the hindlegs and the animal had assumed a ball-like shape. Other observers have noted that the tail was usually coiled like a watchspring in hibernating mice. Coiling of the tail was not always present in torpid mice in these observations.

Awakening reactions were similar to those described by other writers. The animal, upon being warmed and handled, began to revive. Violent shaking usually accompanied this revival. The sense of balance seemed to be restored quite rapidly. Although an animal still had its eyes closed it would regain an upright position if pushed over. The tail was effectively used in these balance-regaining movements in that it was waved vigorously. When sufficiently aroused to take alarm at sudden movements, it would jump away several feet. The jumps were usually quite uncoordinated and inconsistent in direction.

Eleven jumping mice were collected alive and some simple experiments on the inducement of torpidity were conducted. A refrigerator with a temperature of about 45° F. was used.

In Experiment 1 eleven *Napaeozapus* were placed in the refrigerator in separate wire-mesh cages with ample food (rolled oats) and water. Table 1 contains a summary of the experiment. Three mice died after being taken from the refrigerator and allowed to revive.

In Experiment 2 ten *Napaeozapus* were placed in the refrigerator. Five were supplied with food and water throughout the experiment, and the other five were kept without food or water (Table 1). One mouse of the group without food and water died during the experiment, and one mouse of the group with food and water died some time after being taken from the refrigerator.

In Experiment 3 seven *Napaeozapus* were placed in the refrigerator. Four were supplied at first with food only, and three were without food or water (Table 1). During this experiment two mice from each group died.

In summary, in the first experiment eleven *Napaeozapus* were placed in a refrigerator with ample food and water. At the end of 28 hours, 45 minutes four mice had become torpid and seven had remained active. Food and water was then removed and the seven active mice became torpid within 13 hours.

In the second experiment five *Napaeozapus* were given food and water while five others had no food or water. Four mice from the latter group had become torpid within 12 hours, 45 minutes while the five mice with food and water remained active for 20 hours, 45 minutes, when the experiment was terminated.

In the third experiment three mice were kept without food or water while four others were given food only. The former group became torpid within 20 hours, 30 minutes and remained so for at least 70 hours. Within the next 30 hours, two mice had died and one had revived from the experiment. The group with food only remained active for 20 hours, 30 minutes. These mice were then removed from the refrigerator and given food and water. After 22 hours, 30 minutes they were returned to the refrigerator and supplied with water only. They became torpid within 17 hours, 30 minutes, and two had died between the 40th and 57th hour from the initiation of this third experiment. The other two mice revived successfully from torpidity.

No cause can be assigned to the death of nine mice during and after these experiments. Five of these died while torpid, three died after reviving from torpidity, and one died

TABLE 1. — *Experiments on the inducement of torpidity in Napaeozapus*

ELAPSED TIME HRS., MIN.	CONDITION OF MICE, EXPERIMENT 1.
	With food and water
0:00	Eleven mice active
4:45	One torpid, 10 active
7:30	Same mouse torpid, removed from refrigerator; 10 mice active
15:45	One mouse torpid, 9 active
28:45	Three mice torpid, removed; 7 active; food and water removed from refrigerator
	Without food or water
41:45	All 7 mice torpid

ELAPSED TIME HRS., MIN.	CONDITION OF MICE, EXPERIMENT 2.	
	With food and water	*Without food or water*
0:00	Five mice active	Five mice active
12:45	Five mice active	Four mice torpid, 1 active
20:45	Five mice active	Four mice torpid, 1 dead

ELAPSED TIME HRS., MIN.	CONDITION OF MICE, EXPERIMENT 3	
	With food only	*Without food or water*
0:00	Four mice active	Three mice active
12:00	Four mice active	Two mice torpid, 1 active
20:30	Four mice active, removed and given food and water	Three mice torpid, left in refrigerator
	With water only	
43:00	Mice returned to refrigerator with water only	Three mice still torpid, breathing
60:30	Four mice torpid, breathing	Three mice torpid, breathing
70:00	Four mice torpid, breathing	Three mice torpid, breathing
83:00	Four mice torpid, breathing	Two mice torpid, breathing; 1 dead
100:00	Two mice torpid, breathing; 2 dead	One mouse torpid, breathing; 2 dead
	All mice removed from refrigerator and supplied with food and water	
105:00	Two mice active	One mouse active

some time after being taken from the refrigerator in which it was active and supplied with food and water.

Respiration was closely observed in one torpid jumping mouse in the group without food or water in Experiment 3. At the 100th hour of the experiment, breathing of this mouse was observed for three minutes. Respirations counted were: first minute, 5; second minute, 0; and third minute 9. This observation was made immediately after having taken the mouse from the refrigerator.

It appears that the cold of the refrigerator was not a sufficient stimulus to cause the mice to become torpid readily if there was a supply of food available. Without food, the mice soon became torpid. The absence of water alone did not have this effect.

Lyman (Jour. Mamm., 35:545–552, 1954) has pointed out a difference among rodents regarding the conditions which bring on hibernation. The woodchuck accumulates a great deal of fat before hibernation, and in the laboratory can be induced to hibernate by the denial of food (Lyman and Chatfield, Phys. Rev., 35:403–425, 1955). The same is true for the thirteen-lined ground squirrel (Johnson, Biol. Bull., 59:114–127, 1930). On the other hand, the withholding of food will delay the onset of hibernation in the golden hamster which does not accumulate fat before hibernation. This has been correlated with its habit of storing food in the burrow for consumption at times of wakefulness during the period of hibernation (Lyman, *loc. cit.*)

The woodland jumping mouse is apparently similar to the woodchuck and ground squirrel in respect to hibernation. In the fall, jumping mice are found with a large accumulation of fat. Results of experiments described here appear to indicate that the withholding of food induced them to go into a state of torpidity.—HAROLD G. KLEIN, *Department of Conservation, Cornell University, Ithaca, New York. Received March 13, 1956.*

SOUTHERN EXTENSION OF THE RANGE OF THE PIGMY RABBIT IN CALIFORNIA

Severaid (Jour. Mamm., 31: 1–4, 1950) reported the presence of the pigmy rabbit (*Sylvilagus idahoensis*) in the Bodie area, northern Mono County, California. Prior to his observations pigmy rabbits had been reported in California only in Modoc and Lassen counties, 190 miles to the northwest (ORR, THE RABBITS OF CALIFORNIA, Calif. Acad. Sci., 192–201, 1940).

Between 1951 and 1955, while working in Inyo and Mono Counties, I heard several local residents speak of shooting so-called "brush rabbits" in the Crowley Lake area of southern Mono County. Clear distinction was made between these and the abundant cottontail rabbits (*Sylvilagus audubonii arizonae* and *Sylvilagus nuttalli grangeri*) which occur in Inyo and Mono Counties. I have never heard of "brush rabbits" in Inyo County, though habitat identical to that around Crowley Lake occurs along the eastern base of the Sierra Nevada in Inyo County.

On May 23, 1955, Mr. Lloyd Beavers of Whitmore Tubs at the north end of Crowley Lake, told me that "brush rabbits" seemed to live in isolated colonies throughout the plateau area north of Crowley Lake, while cottontails were more evenly distributed. He also stated that a "brush rabbit" had been killed the previous winter on the road about four miles northeast of Whitmore Tubs. On May 23 I also talked to Indian George who had herded cattle in the area for about twenty years. He confirmed Mr. Beavers' statement about the isolated colonies and took me to a spot two miles north of the Cashbaugh Ranch where he said he frequently saw the smaller, darker "brush rabbits." We hiked around for a short time, but saw no rabbits or burrows, though we did notice some sign of small rabbits.

On September 26, 1955, I returned to the same spot and searched more thoroughly. In a slightly different location I jumped a small rabbit at 11:25 A.M. which I noted as being "dark, reddish brown all over, no white tail." In this vicinity I found three burrows, one with one hole, one with two holes and one that appeared to have five holes. There were many urine spots, very small rabbit pellets (averaging 5 mm. in diameter), very small rabbit tracks and sagebrush clippings about each burrow and along trails through the tall sagebrush. The soil of this area is a fine, dusty, pumice sand with a total lack of rocks. The vegetation is a big sage (*Artemisia tridentata*), bitterbrush (*Purshia tridentata*), and rubber rabbitbrush (*Chrysothamnus nauseosus*) growing to a height of 5 feet. The elevation of the area is 6980 feet.

Through lacking the absolute proof of a specimen in hand at this time there is little doubt that the pigmy rabbit occurs in the Crowley Lake area, which is about 60 airline miles southeast of Bodie, the previous southernmost locality of record in California.—FRED L. JONES, *California Dept. of Fish and Game, Sacramento 14, California. Received May 28, 1956.*

AN UNUSUALLY LATE PREGNANCY IN A WISCONSIN COTTONTAIL

A Wisconsin hunter, Mr. John Cerro of Madison, shot an unusually large cottontail (*Sylvilagus floridanus*) on November 21, 1955, in an upland habitat type. On dressing the animal it was found to be a pregnant female. He recognized this as an unusual occurrence and turned the carcass over to the Wisconsin Conservation Department. The humeral epiphysis of the rabbit was completely closed, indicating that she had passed her first winter.

Further dissection showed that there were ten embryos present. They were uniform in size and well-developed. Crown-rump measurements averaged 62 mm. which places their age at approximately 25 days, using C. W. Schwartz's (1942) descriptions. Their appearance and development is similar to that of embryos at the birth stage however. Authorities generally agree that the breeding season ends in September.

The average prenatal litter size, from unpublished Wisconsin Conservation Department data, is six. It ranges from two to ten, with only two occurrences of two, and one of ten. This is from a collection of eighty-two pregnant females made over a five-year period. —C. W. LEMKE, *Wisconsin Conservation Department, Madison. Received May 20, 1956.*

OBSERVATIONS ON THE DISAPPEARANCE OF SHED CARIBOU ANTLERS

The object of this report is to record the disappearance of shed antlers from a section of tundra along the Hudson Bay Railroad south of Churchill, Manitoba, between August, 1951, and August, 1955. Secondarily, I wish to relate these observations with those presented in a recent paper on the Barren Ground Caribou (*Rangifer arcticus arcticus*) by Harper (1955). This writer (p. 50) makes the following remarks: "According to Charles Schweder, the old antlers left at the river crossings from bygone days are superior in size to those of the present day. He himself has never secured a set of antlers equal to one (fig. 25) lying on the shore of Simons' Lake; it may have been there for 20 or 30 years prior to 1947."

Shed caribou antlers remaining untouched on the ground for more than a few years seems to be the exception rather than the rule. Millais (1907:321) states of the Newfoundland caribou: "The females chew the points of every old horn they come across." Hamilton (1939:80) supports this with the comment: "Caribou chew and partially eat their freshly fallen antlers." In Banfield's recent report on caribou (1954, part II:13) he has a short but precise statement which reads, "Discarded antlers are avidly chewed during the winter months." Thus it appears that the caribou themselves rid the countryside of fallen antlers, and in all probability those antlers from shot or accidentally killed animals are likewise consumed.

The tendency for the Cervidae to eat their shed antlers is well known. Darling states in A HERD OF RED DEER (1937:160): "The stags of Western Highland forests waste nothing which can supply them with calcium phosphate, so they eat the stripping velvet from their own or their fellows' antlers. When the antlers are shed they are eaten from the points upwards and the butts only are left." Probably for the same reason, the likelihood of shed antlers remaining long on the ground in caribou range is very slim. Seton (1911: 256) has a drawing of a pair of caribou antlers which is captioned, "Food of ground squirrels. Antlers of caribou." Rodents doubtless also hasten the disappearance of caribou antlers on the tundra. Mice, squirrels, and porcupines account for the disappearance of shed antlers in the forests. The same may be said for moose antlers. Merrill (1920:171) writes: "One often wonders why he so rarely finds in the woods an antler [moose] shed in some previous season. Those which are found are usually mutilated, having been gnawed by the mischievous woods mice or by porcupines."

The disappearance of shed antlers and of those from the skulls of killed caribou was

evident in two trips I made to what Harper (p.12) refers to as the "Little Barrens" south of Churchill, Manitoba. The first trip I made in August and early September, 1951, with Dr. William H. Elder of the University of Missouri and Robert S. Ellarson of the University of Wisconsin. We traveled with William Newman, a Game Guardian of the Manitoba Game Branch. Mr. Newman was on routine patrol to Churchill; we were interested in obtaining information on wolves from trappers and in photographing the habitat change from forest to tundra. Through the cooperation of the Manitoba Game Branch, we were permitted to travel with Mr. Newman in his "gas car." This open vehicle which runs on the tracks of the Hudson Bay Railroad allowed for an unobstructed view of the country. In a 750-mile roundtrip, three of us recorded all birds and mammals observed from the car, traveling about 25 m.p.h. The first caribou antler was seen at Mile 249 (The Pas is Mile O; Churchill is Mile 512). From Mile 249 to Churchill, we saw 60 antlers on both sides of the track. In all but a few cases, these were shed antlers.

In August, 1955, I again returned to the "Little Barrens" and was able to cover much of the same area in the same way as in 1951. I accompanied Game Guardian Robert Burns on his patrol to Churchill. The object of this trip was to collect specimens of willow ptarmigan (*Lagopus lagopus*), so we made numerous stops on the tundra and were constantly alert to objects of biological interest while traveling. Although there was one less observer, our travel rate was much slower and we made a special effort to record all the animals and also the number of shed caribou antlers seen. I was interested in obtaining a good rack of antlers for the University of Wisconsin collection and therefore was on the lookout for all likely prospects.

Unfortunately I did not cover the identical mileage on both trips, but it was evident that the number of antlers observable was greatly reduced. In the area from Mile 349 to Mile 442 a comparison could be made between the two trips. In 1951, 35 antlers were seen; in 1955, only 6. This same magnitude of loss was noted elsewhere where no precise tally was kept.

In attempting to acquire a suitable rack of antlers I examined three sets with attached skulls. Each appeared from the gas car to be intact but on close examination was found to be badly chewed. I managed to get a handsome set (44 points) from a railroad-section foreman who, because of its trophy qualities, had hung it on a shed. The section foreman said that mice and "chipmunks" chew off the "points" so he hung the rack off the ground.

Harry Pienowsky and Emil Buss, trappers who live at Mile 442, told me they had a "mouse" high on the barrens in 1953 and 1954. I saw evidence of extreme browsing on tundra plants, particularly dwarf birch (*Betula glandulosa*) and willow (*Salix* sp.), and also saw piles of rodent dung in greater abundance than I had ever seen before. In a week's hunting in the bush and on the tundra, I did not observe a single live rodent, although I made an effort to do so.

It seems likely that, between 1951 and 1955, caribou and rodents reduced the antlers observable from either side of the Hudson Bay Railroad track. This lends support to literature records which indicate that there is a rapid turnover in shed antlers. It is not impossible that caribou antlers could remain untouched for a considerable period of time, but it seems unlikely.

In summary, shed caribou antlers usually disappear in a few years. Rodent or rodent-like animals and caribou consume the antlers, apparently for the nutritive value. This disappearance was evidenced by a drop in the number of shed antlers observed on an area of tundra along the Hudson Bay Railroad in northern Manitoba between 1951, when about 35 antlers were recorded per 100 miles of the best range, and 1955, when less than 6 antlers were recorded in the same area.

Harper's (*loc. cit.*) remarks stating that antlers remain intact on caribou range for "20 or 30 years" appear to be atypical according to these observations and those recorded in the literature.—ROBERT A. MCCABE, *University of Wisconsin, Madison.* *Received April 26, 1956.*

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THREE ADDITIONAL RECORDS OF ANTLERED FEMALE DEER

The presence of malformed, small antlers in which the velvet was retained was reported for three female white-tailed deer (*Odocoileus virginianus borealis*) by Wislocki (Jour. Mamm., 35:486–495, 1954). Each of these females apparently had been through at least one pregnancy. Wislocki's hypothesis is that during pregnancy an andromimetric steroid or progesterone produced by the corpus luteum may have provided the initial triggering of the hypophysis needed to start the antler cycle. Since the existence of the corpus luteum of pregnancy is temporary, the release of an androgenic hormone must be brief, with the result that insufficient hormone is available for maturation of the antlers or shedding of the velvet. Wislocki does not explain what he means by "brief" existence of the corpus luteum. Presumably, he is considering the time between (1) days in spring with sufficient photoperiod to stimulate the hypophysis so that it responds to the initial triggering by the andromimetric steroid, and (2) degeneration of the corpus luteum after parturition in May or June. Production of andromimetric steroid during the summer presumably would be necessary for continued antler development and a sufficiently high level would be required by August or September to cause the velvet to shed (Wislocki, Aub and Waldo, Endocrinology, 40:202-224, 1947). As in castrated males, the antlers in the velvet are retained permanently by the females (Wislocki, *op. cit.*, p. 494.)

The present report is in response to Wislocki's suggestion to place on record the details of additional antlered female deer. One of the three deer reported here was a whitetail (*Odocoileus virginianus ochrourus*) poached at Peola, Garfield County, Washington, and collected by Game Protector Roy Clark. Apparently this was the same antlered female local farmers saw repeatedly with the two fawns during the summer. The antlers were small, one 85 mm. and the other 120 mm., and covered with velvet. The tips of the antlers were flattened, but unbranched. This female was lactating at the time she was killed on October 20, 1955. Each ovary contained one large pigment scar, as would be anticipated. On the basis of the molariform teeth the animal appeared to be two and a half years old.

The second female, also *O. v. ochrourus*, was killed by Noe Higinbotham on November 19, 1955, two miles east of Deary, Latah County, Idaho. The antlers were in the velvet, one being about 85 mm. long and the other about 50 mm. long; neither antler was branched. The ovaries of this animal were not collected. From the appearance of the udder this female had been lactating. Judging by the wear on the molariform teeth, she was about four and a half years old.

The third antlered female was a mule deer (*Odocoileus hemionus hemionus*) killed in the Frazier Creek area, Okanogan County, on October 21, 1955. The skull was collected from the hunter by Fred C. Zwickel, District Biologist, State of Washington Department of Game. Both antlers were in the velvet, one being about 25 mm. long and slightly branched, the other unbranched and about 85 mm. long. This female was lactating. Tooth wear indicated that this animal was very old, probably more than ten years of age.

The evidence from these three female antlered deer is consistent with Wislocki's hypothesis.—HELMUT K. BUECHNER, *Department of Zoology, State College of Washington, Pullman.* *Received May 10, 1956.*

PRE-COLUMBIAN HORSES FROM YUCATAN

The remains of horses have been reported from cave deposits in the state of Yucatan, Mexico, on two previous occasions. Mercer (THE HILL CAVES OF YUCATAN, Lippincott, Phila., 1896, p. 172 and map opposite title page) found horse remains in three caves in the Serrania, a low range of limestone hills lying in southwestern Yucatan and trending roughly parallel to the southwestern border of that state. The horse material was associated with pot sherds and other artifacts and showed no evidence of fossilization. Cope (*in* Mercer, *op. cit.*, p. 172, footnote) examined the material and considered it referable to *Equus occidentalis* on morphological characteristics but noted the absence of fossilization.

Hatt records numerous fragments of *Equus ?conversidens* from Actun Lara, one of Mercer's caves (1953, Cranbrook Inst. Sci., Bull. 33, pp. 71–72 and map 2). These remains were tentatively referred to *Equus tau* by R. A. Stirton (*in* Hatt, p. 71). Hibbard regards *E. tau* as probably synonymous with *E. conversidens* (1955, Contrib. Mus. Paleo. Univ. Mich., 12:61). Although the teeth and bones were in many cases heavily encrusted with lime, pottery occurred throughout the deposits and two foot bones present in the upper of two layers in which horse remains occurred were identified as those of domestic cattle.

It is now possible to report horse remains of probable pre-Columbian age from a new locality in Yucatan. This material consists of one complete upper molar and 3 fragmentary lower molars, all preserved in the Museum of Comparative Zoology (Cat. no. 3937). The teeth constitute a part of a large collection of vertebrate remains obtained by archeologists of the Carnegie Institution of Washington during excavation at the Mayan ruins of Mayapan, Yucatan (20°38′N., 89°28′W.). This collection was submitted to the author for identification, and a checklist of the material is in preparation. The horse teeth were collected in cenote Ch'en Mul (Section Q, topographic map of the ruins of Mayapan, Jones, Carnegie Inst. Washington, Dept. Archeology, Current Rept. 1, 1952) from the bottom stratum in a sequence of unconsolidated earth almost 2 meters in thickness. As in the deposits reported by Mercer and Hatt, pottery occurs throughout the stratigraphic section. The horse teeth are not specifically identifiable. They are considered to be pre-Columbian on the basis of depth of burial and degree of mineralization. Such mineralization was observed in no other bone or tooth in the collection although thousands were examined, some of which were found in close proximity to the horse teeth.

It is by no means implied that pre-Columbian horses were known to the Mayans, but it seems likely that horses were present on the Yucatan Peninsula in pre-Mayan time. The tooth fragments reported here could have been transported in fossil condition as curios by the Mayans, but the more numerous horse remains reported by Hatt and Mercer (if truly pre-Columbian) could scarcely be explained in this manner.—CLAYTON E. RAY, *Museum of Comparative Zoology, Cambridge, Mass.* *Received May 28, 1956.*

LONGEVITY OF CAPTIVE MAMMALS

Most longevity records are based on specimens in captivity and probably often exceed what may be expected in wild populations. Still, as indications of potential life-span, they may be useful to various workers. Since the opening of the Bronx Zoo in 1899, a number of longevity records have been established in its mammal collection. Many of these were summarized by Wm. Bridges (Bull. N. Y. Zool. Soc., 35: 89–98, 1935); more recently, others were recorded by L. S. Crandall (Animal Kingdom, 52: 175–177, 1949). The tabular data below bring the record partially up to date.

TABLE 1. — *Longevity records of individual specimens*

SPECIES, SEX	DATES OF ARRIVAL AND DEATH	KNOWN AGE (YR.-MO.-DA.)	REMARKS
Ornithorhynchus anatinus, Platypus, ♂ and ♀	26 April 1947, still living	9- 9- 0	Born about Dec., 1945
Erinaceus europaeus, European hedgehog, ♀	29 Oct. 1951, 7 Oct. 1955	3-11- 8	Adult on arrival
Potos flavus, Kinkajou, ♂	6 Aug. 1937, still living	19- 5- 0	
Panthera tigris, Bengal tiger, ♀	11 April 1934, 5 Sept. 1952	18- 6-24	At least 1 yr. old on arrival
Panthera uncia, Snow leopard, ♂	8 May 1946, 23 Jan. 1955	8- 8-15	Born 1945
Phloeomys cumingi, Giant rat, ♀	9 July 1947, still living	9- 6- 0	
Nycticebus coucang, Slow loris, ♀	10 Nov. 1948, still living	8- 2- 0	
Galago crassicaudatus, Grand galago, ♀	13 May 1944, still living	12- 8- 0	Born in captivity
Phacochoerus aethiopicus, Wart hog, ♀	15 Nov. 1940, 30 Jan. 1956	15- 2-15	
Hippopotamus amphibius, Nile hippopotamus, ♂	13 July 1903, 1 Feb. 1953	49- 6-19	Born in captivity
Choeropsis liberiensis, Pigmy hippopotamus, ♂	9 July 1912, 17 Feb. 1952	39- 7- 8	
Lama glama, Llama, ♂	17 Nov. 1904, 7 April 1926	21- 4-21	Born in captivity
Cervus unicolor, Sambar deer, ♀	5 July 1929, 12 Dec. 1955	26- 5- 7	
Okapia johnstoni, Okapi, ♂	3 Aug. 1937, 5 Sept. 1952	15- 1- 2	
Bibos frontalis, Gayal, ♀	21 Aug. 1944, still living	12- 5- 0	Born in captivity
Anoa depressicornis, Pigmy buffalo, ♀	16 July 1928, 10 Jan. 1957	28- 5-25	Born in captivity
Equus burchellii, Chapman's zebra, ♂	19 May 1929, 4 April 1954	24-10-16	At least 3 yrs. old on arrival
Rhinoceros unicornis, Indian rhinoceros, ♀	24 May 1923, still living	33- 8- 0	Born 1920

The figures above are not all necessarily the longest records available, but they do represent exceptional longevities in captive mammals. "Known age" is based on dates in captivity and frequently may be augmented as indicated under "remarks." Data have been corrected as of January, 1957. All specimens were in the collection of the Bronx Zoo except the Chapman's zebra, which resided at the Prospect Park Zoo in Brooklyn, N.Y.—RICHARD H. MANVILLE, *New York Zoological Society. (Present address: 151 Ossining Road, Pleasantville, N.Y.)* *Received June 28, 1956.*

POTENTIAL LONGEVITY IN SOME MAMMALS

In the *Journal of Mammalogy* (37:118) Comfort discusses the maximum ages reached by domestic cats, and concludes that the cat appears to be quite the longest-lived of the smaller domestic animals, occasionally reaching about 30 years. It may be of interest to add the following notes on two of the larger domestic mammals, the cow and the horse. My attention was drawn, by a note in the Spring *News Letter* for 1956 of the National Trust for Places of Historic Interest or Natural Beauty, to "what is believed to be the oldest cow in the world (aged thirty-nine years) at West Hook Farm," in Pembrokeshire, South Wales. Enquiries to Miss Gwendoline E. Davies, the owner of the cow, elicited the following information. The cow (a Hereford cross with a Black) was born, Miss Davies informs me, at Dale, Pembrokeshire, in May 1916, and was looked after by Miss Davies from then up to the present time. During her life the cow has had over 30 calves and yielded milk up to approximately three years ago; though she is stated to be "getting very stiff now." The claim that this is the oldest cow in the world, or at least the oldest recorded cow, would appear to be justified. Flower (Proc. Zool. Soc. London, 1931, 204) remarks that "The Domestic Ox, *Bos taurus*, seldom gets a chance of growing to old age." The greatest age for a domestic cow definitely quoted in his paper is 16 years 10½ months, though this animal was supposed to be in fact about 20 years old. The cow mentioned above died on July 1, 1956.

In the same paper, Flower mentions that the oldest age claimed for the horse, a Manchester canal horse which died on November 27, 1822, is 62 years. Additional information about this horse is given by R. S. Summerhays in an article in the issue of *Country Life* for March 8, 1956. He writes of "the 62-year-old gelding Old Billy. . . His age needed no authentication, for Henry Harrison at the age of 17 first had him as a two-year-old, when he trained him to plough, and afterwards as a gin, or mill horse, and at his death on November 27, 1822, the old horse had been owned for many years by the Company of Proprietors of the Mersey and Irwell Navigation Company and had been used as a barge-horse. Henry Harrison knew him throughout his long life, Charles Towne and William Bradley painted him, his picture hangs in the Council Chamber of the Royal Veterinary College, and the skeleton of his skull was presented to the Manchester Museum." Mr. Edmund L. Seyd of the staff of the Manchester Museum informs me that the skull is still in that institution, and adds, "The skull is certainly that of a very old horse, some of the teeth being heavily worn, although a lot of this wear has clearly been caused by the bit."

It may be well to take this opportunity of republishing the record of a Grey Seal, *Halichoerus grypus*, a male, which reached the age of at least 41 and possibly 42 years in the zoological gardens at Skansen, Stockholm. This record, published by the writer in 1950 (Nature, 166:73) has been overlooked by Bourlière in his NATURAL HISTORY OF MAMMALS (1955), where the table of potential longevities on pp. 201–2 still gives Flower's figure of 18 years as the maximum for the Grey Seal.—COLIN MATHESON, *Department of Zoology, National Museum of Wales, Cardiff.* *Received May 5, 1956.*

PREDATION ON SMALL MAMMALS IN THE DISMAL SWAMP, VIRGINIA

It is well known that small mammals are preyed upon by larger animals and are important in the food chains of most terrestrial communities. A great deal of information on this subject has already been published. However, since much remains to be learned, the author is prompted to present this brief note on predation in the Dismal Swamp area of southeastern Virginia.

On July 4, 1954, a large copperhead snake (*Ancistrodon contortrix* Linnaeus) was captured as it swam in a small stagnant pond at the edge of the swamp. Dissection of its stomach revealed the partly digested remains of a short-tailed shrew (*Blarina telmalestes* Merriam). The copperhead is common on the edges of the Dismal Swamp.

In Princess Anne County, east of the swamp, on February 12, 1956, I secured a saw-whet owl (*Aegolius acadica* Gmelin) that had been killed by a car. Its stomach contained remains of a house mouse (*Mus musculus* Linnaeus). The saw-whet owl is a casual visitor in this area.

On March 31, 1956, on the western edge of the swamp, I found three large pellets in a pine thicket that was the abode of a barred owl (*Strix varia* Barton.). The pellets contained remains of at least eight individuals of four species of mice and shrews: 1 short-tailed shrew (*Blarina telmalestes* Merriam), 4 meadow mice (*Microtus pennsylvanicus* Ord), 2 pine mice (*Pitymys pinetorum* Le Conte), and 1 house mouse (*Mus musculus* Linnaeus). The barred owl is common throughout the swamp.

I am grateful to C. O. Handley, Jr., of the Smithsonian Institution, for confirmation of identifications and review of the manuscript.—R. H. Rageot, *Norfolk Museum, Norfolk, Virginia. Received April 18, 1956.*

SOME ECTOPARASITES FROM INDIANA MAMMALS

Recently the author had the opportunity to study some ectoparasitic Acarina and Insecta in the collection of the Joseph Moore Museum, Earlham College. The following is an initial list on the ectoparasitic fauna of Indiana.

All specimens have been catalogued and permanently mounted on microscope slides or preserved in 70 per cent alcohol. The collector and catalogue number in the writer's collection are included with the data pertaining to each specimen. Each entry of data represents a collection from a different individual. Acknowledgment is extended to J. B. Cope, Curator, Joseph Moore Museum, for permission to study the collection and to the following specialists for their help on some of the identifications: G. M. Kohls, U.S. Public Health Service, Hamilton, Montana (Ixodides); W. H. Lawrence and K. L. Hays, School of Natural Resources, University of Michigan, Ann Arbor, Michigan (Siphonaptera and *Laelaps alaskensis* respectively); T. J. Spilman, U.S. Department of Agriculture, Beltsville, Maryland (Leptinidae). The remaining mites, anoplurans, and mallophagans were identified by the author. The list of mammal hosts, and their ectoparasites, follows.

TALPIDAE

Scalopus aquaticus (Linnaeus)—Wayne Co., Centerville, 9 March 1954, H. Cope, host to 12 fleas, *Ctenophthalmus pseudagyrtes* Baker, 1 mite, *Haemolaelaps glasgowi* (Ewing), and 2 beetles, *Leptinus testaceus* Müller (E22). Indiana is one of four states from which there is no definite record of *H. glasgowi* (Pratt and Good, Jour. Parasit., 40: 113–129, 1954). Whether *L. testaceus* is a parasite or merely a nest scavenger is not known definitely though Comstock (An Introduction to Entomology, Comstock: 487, 1949) believes it to be the latter. Wayne Co., Centerville, 13 March 1954, H. Cope, host to 1 flea, *Ctenophthalmus pseudagyrtes* Baker (E18).

LEPORIDAE

Sylvilagus floridanus (Allen)—Wayne Co., Centerville, 25 May 1953, J. B. Cope, host to 1 tick, *Haemaphysalis leporis-palustris* (Packard), (E13); Wayne Co., Centerville, 7 Jan. 1956, J. B. Cope, host to 4 fleas, *Cediopsylla simplex* (Baker), (E143).

SCIURIDAE

Marmota monax (Linnaeus)—Wayne Co., Richmond, Aug. 1955, G. L. Ward and Woofer, host to 1 tick, *Ixodes cookei* Packard (E146).

Sciurus niger Linnaeus—Jefferson Co., Deputy, 5 June 1953, N. Wilson, host to 1 flea, *Orchopeas howardii* (Baker) and 1 tick, *Dermacentor variabilis* (Say), (E8); Decatur Co., Horace, 20 Dec. 1955, N. Wilson, host to 46 lice, 5 *Hoplopleura sciuricola* Ferris, 1 *Neohaematopinus sciurinus* (Mjöberg), and 40 *Enderleinellus longiceps* Kellogg and Ferris (E122). *H. sciuricola* is reported from nine species of squirrels, not including *S. niger*, by G. F. Ferris (Mem. Pacific Coast Ent. Soc., 1: 294–295, 1951).

Tamiasciurus hudsonicus (Erxleben)—Wayne Co., Earlham College Campus, 12 March 1953, M. Bloemker, host to 1 flea, *Orchopeas howardii* (Baker), (E24).

CRICETIDAE

Peromyscus leucopus (Rafinesque)—Posey Co., Hovey Lake, 31 Dec. 1954, N. Wilson, host to 1 flea, *Epitedia wenmanni* (Rothschild), (E20); Posey Co., Hovey Lake, 31 Dec. 1954, N. Wilson, host to 8 lice, *Hoplopleura hesperomydis* (Osborn), (E20).

Synaptomys cooperi Baird—Harrison Co., Harrison State Forest, 30 Dec. 1955, N. Wilson, host to 1 mite, *Laelaps alaskensis* Grant (E133).

Microtus ochrogaster (Wagner)—Jackson Co., Freetown, 9 Jan. 1953, R. E. Mumford, host to 1 flea, *Epitedia wenmanni* (Rothschild), (E26); Harrison Co., 6 Jan. 1955, R. E. Mumford, host to 1 flea, *Stenoponia americana* (Baker) and 2 mites, 1 *Laelaps kochi* Oudemans and 1 *Haemogamasus barberi* Ewing (E10).

Pitymys pinetorum (Le Conte)—Harrison Co., 6 Jan. 1955, R. E. Mumford, host to 1 flea, *Stenoponia americana* (Baker) and 6 mites, *Haemogamasus barberi* Ewing (E17).

PROCYONIDAE

Procyon lotor (Linnaeus)—Wayne Co., T. 13 N., R. 2 W., Sec. 6, 20 Feb. 1953, J. Tileston, host to 1 tick, *Ixodes cookei* Packard (E15); Wayne Co., Richmond, 23 April 1954, G. L. Ward, host to 1 tick, *Ixodes texanus* Banks (E12). This tick is damaged and G. M. Kohls (personal communication, 21 June 1955) informs me it is probably *texanus*. Franklin Co., Fairfield, 13 Jan. 1956, J. B. Cope, host to 12 fleas, *Chaetopsylla lotoris* (Stewart), (E140).

MUSTELIDAE

Mephitis mephitis (Schreber)—Wayne Co., T. 13 N., R. 2 W., Sec. 6, 14 Feb. 1953, G. L. Ward, host to 7 ticks, *Ixodes cookei* Packard (E11); Wayne Co., Centerville, 2 June 1954, M. Bloemker, host to 2 lice, *Trichodectes mephitidis* (Packard), (E33).

SUMMARY

Study of a collection of ectoparasitic Acarina and Insecta from Indiana resulted in the reporting of one species of beetle, six of fleas, five of lice, four of ticks, and four of mites from eleven species of mammals.—NIXON WILSON, *522 North Third Street, Bardstown, Ky.* *Received May 7, 1956.*

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REVIEWS

Stresemann, E. (Editor). EXKURSIONSFAUNA VON DEUTSCHLAND. WIRBELTIERE. Volk und Wissen Verlag, Berlin. Pp. xii + 340, 250 figs., 46 tables. 1955. Price, DM 7.50 (cloth).

This handy field guide, as stated in the editor's foreword, is intended for nature lovers of all ranks, from the layman to the university professor and his students. It consists of chapters on fishes by K. Deckert and G. Bauch, amphibians by G. E. Freytag, reptiles by H. Wermuth, birds by W. Makatsch and mammals by K. Zimmermann.

Although the last chapter covers only 54 pages of the guide, it presents in a condensed form a large amount of up-to-date information on the morphology, distribution, habitats and habits of more than 75 species of native and introduced German mammals; a list of the latter consists of six species including the nutria, golden hamster, muskrat, American mink, sika deer and mouflon.

The keys for identification of genera and species are quite simple to use, and together with numerous black-and-white drawings will be helpful to any devotee of mammalogy. The five distributional maps also contribute to the value of the guide.

A few minor errors have escaped the author's notice. To quote one, on page 324 we read about deer: "Kümmerformen in Schottland u. Norwegen, starke Hirsche in *SO-Eur. (Maral)* u. Altai bis N-Am (Wapiti)." (The italics are the reviewer's.) According to Flerov ("Mammals" *in* FAUNA OF THE U.S.S.R., 1952) "Maral" and "Wapiti" are the common names of the same species (*Cervus elaphus canadensis* Erxleben) which in its distribution in Asia does not go east of Tian Shan Mountain Range; i.e., the present range of this species does not include any part of Europa at all.

Among the occasional typographical errors, the one on page 293 may cause some confusion for the beginners: in the remarks on the second pair of incisors in the upper jaw of lagomorphs, the symbols refer to the lower jaw; nor has this particular characteristic of lagomorphs been clearly explained at the beginning of the chapter (p. 275).

It is the reviewer's opinion that the primary objective of the guide would have been furthered if drawings of the tracks of at least the more common terrestrial mammals had been included.

In general, the chapter on mammals in Stresemann's field guide makes a favorable impression. Written by an authority in the field, it has much detailed information reaching beyond the scope of the guide, which increases the value of the publication for those interested in mammalogy.—W. PRYCHODKO.

Van den Brink, F. H. ZOOGDIERENGIDS. (A field guide to the mammals of Europe west of 30° E. longitude, in Dutch.) Elsevier, Amsterdam. 321 pp., illus. 1955.

This sister volume to Burt's FIELD GUIDE TO THE MAMMALS, covering Europe west of 30° E. longitude, is a new worth-while addition to the Peterson Field Guide Series. An English edition will appear shortly.

This guide includes several improvements over Burt's publication: for each species, information is presented regarding its habitat and habits. The distribution is not described in the text, since it would duplicate data on range maps, which are given for each species mentioned in the text. At the end of the guide is explained why certain names were accepted or discarded. Also useful is a short discussion of what constitutes a species.

The author shows that he has a thorough knowledge of the literature on the subject. He must have spent much time on the preparation of this guide, which describes 173 different species.

Illustrations were prepared by the French painter Paul Barruel. They are of outstanding quality, and include twenty colored and four black-and-white plates. Many useful drawings of tracks and teeth also illustrate the text. A criticism might be that most mustelids pic-

tured are too heavy-bodied, and that the illustration of the tarpan is not "mouse-grey," as mentioned in the text. Excellent photographs of 57 skulls are included.

The greatest contribution of the guide is undoubtedly the range maps, considering that never before has an effort been made to produce such maps for Europe. Apart from native species, a few introduced species are described as well.

Undoubtedly the author's viewpoint concerning the nomenclature and subspecific status of certain forms will disagree with that of others. In particular, his discussion of the genus *Arvicola* appears to be open to criticism. On page 199 the author mentions that he considers all wild sheep of Europe, Asia and America to belong to one species.

Among minor criticisms is the description of the summer coat of the gray squirrel as having marked brown stripes along the sides, undoubtedly a reference to the fulvous appearance. The sable is described as inhabiting underbrush, while probably it is meant that it is largely terrestrial in habits. Based on the experience of the Russians, I would say that it may not be difficult to reintroduce the sable into suitable habitat. All in all, however, it is difficult to find fault with this excellent guide, and the author should be congratulated for his effort.—ANTOON DE VOS.

Rainey, Dennis G. EASTERN WOODRAT, NEOTOMA FLORIDANA: LIFE HISTORY AND ECOLOGY. Univ. Kansas Publ., Mus. Nat. Hist., vol. 8, no. 10, pp. 535–646, 12 pl., 13 figs. August 15, 1956.

Despite the general interest in pack rats and their habits, and their wide distribution over North America, detailed studies have been made of only a few of the many species. This is the first exhaustive study of the eastern woodrat which, in nine different races, ranges from South Carolina to central Texas and from Nebraska to southern Florida. The account is based largely on live-trapping in eastern Kansas from 1951 to 1954, during which 105 woodrats were captured 660 times on the 58-acre study area. In this region the species is highly dependent on osage orange hedgerows which furnish both the preferred food and habitat.

Discussed in detail are such subjects as habitat relationships, reactions to heat, cold and light, behavioral traits, breeding habits, development and survival, predators and competitors, pelage changes, and populations. The elaborate stick houses, adorned with various strange objects attractive only to woodrats, are described and illustrated; their basic pattern is "a system of tunnels above and below ground, a chamber for storing food, a nest, and a fecal depository. The measure of success of a house is the length of continual occupancy." Common commensals in these houses are spiders, isopods, harvestmen, a variety of larval and adult insects, box turtles, skinks, white-footed mice, and cottontails. It seems unfortunate that many ecological data, e.g. home range, territoriality, movements, dispersal of young, and longevity, are treated separately only in a previous number of this series. A bibliography lists 73 references.

There is an interesting consideration of homeostasis as an ecological principle applied to woodrats. Even more than the beaver, muskrat or harvest mouse, which build shelters, or the pika, which cures and stores hay, the woodrat is able to modify its environment and render it relatively stable. Furthermore, throughout its range it faces a wider variety of environmental conditions. Yet, inside its house, it creates a microenvironment largely independent of fluctuating conditions outside, enabling the woodrat to reproduce, rear its young, and feed successfully. This trait increases the limits of tolerance to the environment and permits the invasion of new habitats. "In general," the author concludes, "a stable environment is the key to success of animals." Still, this home atmosphere seems to have induced an inability to react without hesitation in time of danger, when in unfamiliar surroundings. And again, the whims of nature may disrupt the nice adjustments achieved by woodrats, as when a storm in 1949 left a coating of ice that persisted for 21 days; the woodrat population declined abruptly and failed to recover during the course of the study.—RICHARD H. MANVILLE.

Davis, David E. (Compiler). MANUAL FOR ANALYSIS OF RODENT POPULATIONS. Lithoprinted by Edwards Brothers, Inc., Ann Arbor, Mich. Pp. iv + 82, 10 figs. 1956. Price $1.00 (paper) from D. E. Davis, Division of Vertebrate Ecology, The Johns Hopkins Univ., Baltimore 5, Md.

This manual is an outgrowth of the NACSM program begun in 1948 and recently reactivated under the direction of Dr. Davis. However, it "is emphatically not written for the experienced mammalogist or vertebrate ecologist," but rather for foresters, population geneticists, entomologists, rodent control officers, agricultural agents and others interested in population dynamics. It should also prove useful as a guide for field exercises in ecology and mammalogy courses, and certainly there is much here to aid the serious student in organizing his research. Contributors to this work, besides Davis, are Lowell Adams, J. J. Christian, V. F. Flyger, F. K. Hilton, R. Lord, R. Mansueti and R. Traub.

The arbitrary procedure recommended—and this technique may be varied with the needs—is based on the "mark and release" method employing 54 traps, at 50-foot intervals, on a grid of 400 x 250 feet. Aids to obtaining data on population numbers, reproduction, mortality and movements of small mammals are presented, but not to interpretation of these data. There are sections dealing with preparing traps, use of baits, laying out grids, marking animals (by toe-clipping), determining age and sex, checking breeding condition, keeping records and estimating population levels. Four appendixes are concerned with collecting ectoparasites, blood samples and organs for histological study, and with estimating seed consumption. The graphs and other illustrations serve well to elucidate many of the points presented.

Information is scattered rather inconveniently throughout the booklet. The body of the text comprises the first 42 pages; this is followed by 25 pages of Comments, amounting to extended footnotes, which might easily have been consolidated with the earlier sections. There is, unfortunately, no index, and the Contents contains no page citations. A list of References includes 40 titles pertaining to the Notes and Comments section. It is somewhat surprising, in a work bearing this title, to find mention of papers on the otoliths of bony fishes, plumages of birds, populations of snakes, and even on the horns of Dall's sheep and annular ridges of pinniped teeth. Numerous typographical errors testify that the booklet was rather hurriedly assembled. Nonetheless, it does contain in concise form much material useful to the student of small mammal populations.—RICHARD H. MANVILLE.

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COMMENTS AND NEWS

ANNUAL MEETING

The thirty-seventh Annual Meeting of the Society will be held at the University of Kansas at Lawrence, June 17–20, 1957. The Directors' Meeting will be the evening of June 17, with formal sessions beginning the next morning. For further details see the February issue.

ZOOLOGICAL NOMENCLATURE

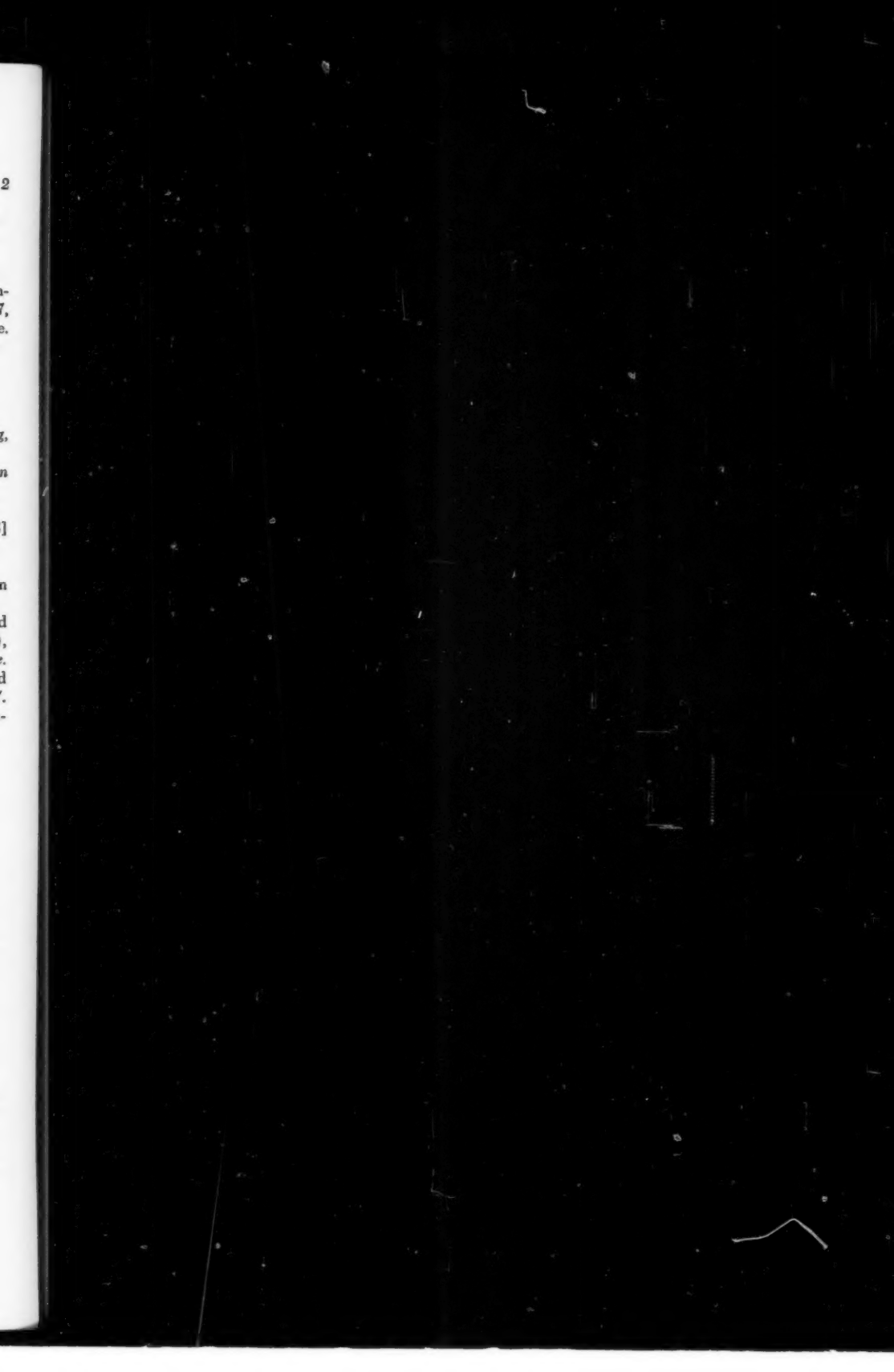
The following is abstracted from a communication recently received from Francis Hemming, Secretary to the International Commission on Zoological Nomenclature:

Notice of proposed use of the Plenary Powers in certain cases for the avoidance of confusion and the validation of current nomenclatorial practice (A. [n.s.] 35).

(1) Applications in Double-Part 2/3, Vol. 13, *Bull. Zool. Nomencl.*:
MUNTIACINAE Pocock, 1923, and ODOBENIDAE Allen (J. A.), 1880, validation of (Z.N. [S] 1187);

(2) Application in Part 4, Vol. 13, *Bull. Zool. Nomencl.*:
Vespertilio murinus Linnaeus, 1758, type species of *Vespertilio* Linnaeus, 1758, clarification of interpretation of (Z.N. [S] 947).

Comments on these applications are invited from any interested specialists. They should be addressed to the Secretary (28 Park Village East, Regent's Park, London N.W. 1, England), clearly marked with the Commission's File Number as given above, and sent *in duplicate*. Comments in response to this Notice will be published in the *Bull. Zool. Nomencl.* provided they reach the Secretariat of the International Commission not later than September 29, 1957. Comments received too late to be so published will be brought to the attention of the Commission at the time of the commencement of voting on the application in question.

DEATH REPORTED

John T. Zimmer, January 6, 1957